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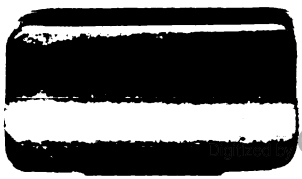
Agric.- Forestry



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UNIV. OF
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REPORT

OF THE

COLLEGE OF AGRICULTURE

AND THE

AGRICULTURAL EXPERIMENT STATION

OF THE

UNIVERSITY OF CALIFORNIA

From July 1, 1916, to June 30, 1917

CONTAINING

Director's Report, 1916-17
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Circulars 152-165
War Emergency Leaflets

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY
1917

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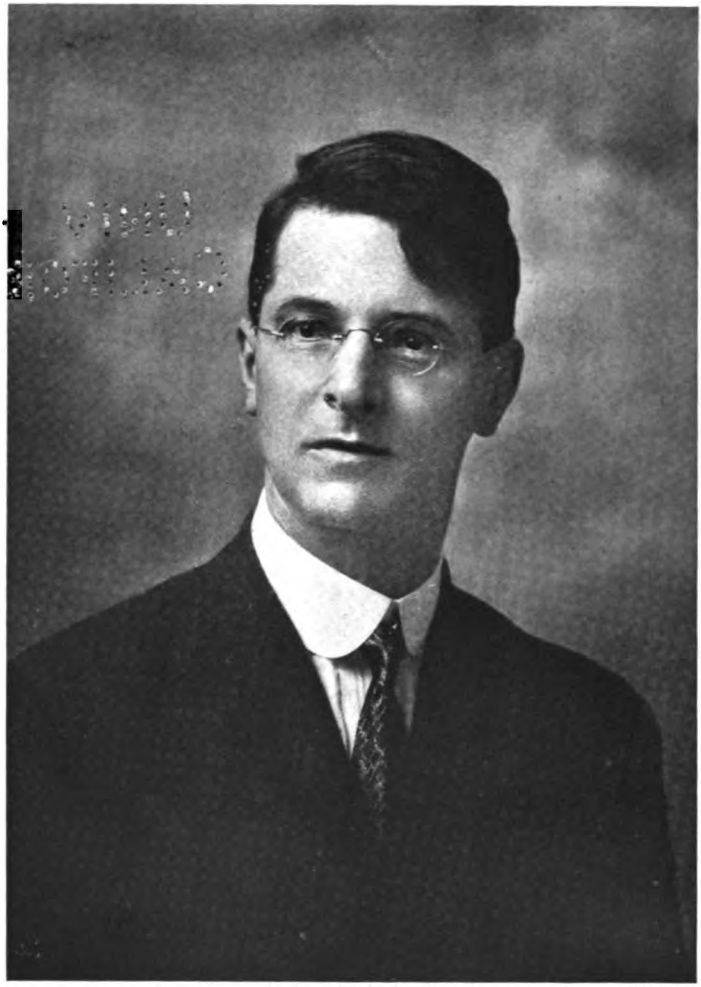

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U. OF CALIFORNIA

REPORT OF THE DIRECTORS

BERKELEY, CAL., June 30, 1917.

To the President of the University of California:

The annual report of the College of Agriculture last year dealt chiefly with current research activities and results of investigations which the Experiment Station had been unable to undertake either through lack of time, facilities, or funds. This year the report deals chiefly with non-resident instruction, popularly known as extension work. It also includes a statement of some of the activities of the department made necessary by the great movement in which this country is engaged to increase the food supply for our allies.

THE COUNTY FARM BUREAU

The County Farm Bureau organization, which the College has been developing since July 1st, 1913, in co-operation with the U. S. Department of Agriculture, has proved of service in connection with the present great crisis, and has been largely extended through an allotment from the emergency appropriation given by Congress to the Secretary of Agriculture. The College has further supplemented this field of service by the use of a considerable number of the members of the staff who are ordinarily chiefly engaged in research or resident instruction. The willingness with which the members of the staff have adjusted themselves to meet these new conditions and the enthusiasm with which they have entered upon their new work is inspiring. It is rather surprising that a movement which is so far-reaching and which had to be built up without previous experience as a guide and without men trained in the details of the work has gone forward with so few difficulties. It is proposed now after a lapse of four years to discuss some of the broader aspects of the administration of this great movement and certain of the general and local difficulties which have arisen or may be expected to arise from time to time.

FARM ADVISERS

Naturally an important consideration is men. Since the aim of the farm adviser is to make available the researches of the United States Department of Agriculture and of the several experiment sta-

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tions and allied investigational agencies, a sound scientific, as well as practical training for him is essential. The successful farm adviser must be trained in scientific methods; viz., must be able to weigh evidence accurately, and must be familiar with the actual findings of a fairly considerable body of agricultural investigations. Since it is not humanly possible for any man to keep intimately informed concerning all phases of agricultural knowledge, a prime essential to the success of a farm adviser is association with a large body of specialists to whom he can go for counsel and advice.

It is of course true that in any given county the agricultural practices of the more successful farmers are in advance of the average practice. Hence the first duty of the farm adviser is to study the practices of the successful men, and having carefully analyzed the reasons for their success to bring his knowledge to the less well informed. Here again a training in the scientific method of approach is of great importance. The author of a recent popular novel makes one of his characters speak of the British military officers as having "hearsay minds." This is a common failing of human beings and one which a farm adviser must be trained to avoid.

Valuable as it is, however, it is not enough merely to spread within the county the practices of the more successful farmers. "Water can never rise higher than its source." Progress must finally come to a standstill unless the successful are in some way made more efficient. These considerations have determined the general policy of appointing to the positions of farm advisers men scientifically trained, even though at the beginning they may lack that fund of experience in local practical affairs which is so essential to the highest success.

It was at once evident that the number of suitably trained men was limited. A further policy was adopted of training men for this work. This is done by appointing recent graduates as assistant farm advisers, and requiring two years of field experience before permitting them to act as farm advisers. This plan has been in operation for three years and has worked well.

It has been found that no matter how much training of a scientific or practical character a man may have, nor however successful he may have been in allied fields of work, he needs experience in this particular enterprise before being given charge of a county. In order to meet the present need for men caused by the Federal Emergency appropriation for Farm Bureau work, a plan has been adopted of appointing men of successful experience in agricultural methods as associate farm advisers and giving them some training under a farm adviser before placing them in charge of a county.

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From the above discussion, it is obvious that many of the farm advisers are comparatively young men. Of the seventeen farm advisers, eleven registered for military service on June 5th, 1917. The average age of the seventeen men on July 1st, 1917, was 30.7 years. The comparative youthfulness, though a handicap in many ways, is not without its compensation. Only a man of great physical endurance can stand the work that the farm adviser is called upon to do. In addition to working all day, answering inquiries and visiting farms, the farm adviser must attend three night meetings each week on a definite schedule, from which he does not usually return until the middle of the night. For example, during the calendar year 1916 there were held 1886 meetings under the auspices of the Farm Bureaus in fourteen counties. In addition to this the farm advisers addressed 213 other meetings. The total attendance in all such meetings was 99,097, an average of 47.2 persons per meeting. Based upon this work each farm adviser each week visits 13.4 farms, holds 2.5 meetings with an average attendance of 47.2 and travels 286.6 miles.

THE BOARD OF SUPERVISORS

The method of financing of the office of the farm adviser is based on an idea to which public expression was first given by President Taft in an address in Kansas City in which he advocated that each of the two thousand or more agricultural counties of the United States should have an agricultural instructor financed jointly by the federal, state, and county governments. Not only has this method of financing been found to be sound but experience has shown that other methods of financing, such as money appropriated by commercial organizations, chambers of commerce, or associations of farmers, are unsound and sooner or later lead to difficulties of more or less serious character. Too much emphasis can not be placed on the fundamental character of this joint method of financing and upon the type of organization which follows from it. As time progresses and the significance of this unique relationship becomes better understood, it will probably have a marked influence on governmental policies in general.

Under the arrangement now constituted by law the funds for the support of the farm advisers are appropriated (1) by the Congress of the United States, (2) by the state legislature, and (3) by the county supervisors. Neither the Congress of the United States nor the state legislature is charged with the execution of laws, but separate branches of the federal and state governments are created for such purposes. The execution of this particular law is in the hands of the United States Department of Agriculture, representing the Congress of the

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United States, and the colleges of agriculture, representing the state legislatures. In the counties there is no legally constituted agency which stands in the same relation to the appropriating agency as does the United States Department of Agriculture to the federal government or the college of agriculture to the state. It has been the policy therefore to look upon the Farm Bureau, although it is not legally so constituted, as standing in the same relation to the interest of the county as the college of agriculture to the state, or that of the United States Department of Agriculture to the federal government.

The general policy concerning the work within a county is worked out with the advice of the directors of the Farm Bureau. The supervisors determine whether it is a movement which they desire to support by an appropriation. If, after trial, the movement does not seem to be valuable, the supervisors may not reappropriate funds at the expiration of their contract, since the appropriation is entirely a voluntary matter. This actually happened in Ventura County. After the farm-bureau system there had been in operation for two and one-half years, the farm adviser was promoted to the position of assistant state leader and a new man assigned to the county as farm adviser. The Board of Supervisors promptly discontinued the work despite a written agreement made by them with the college of agriculture to continue the work for three years. This action may be expected to occur in different counties from time to time. Unless the farmers feel a definite and positive interest in the system after a thorough trial in a given county, it may well be questioned whether it should be continued.

In two instances, one officially, and one unofficially, the college was asked by the supervisors to remove the incumbent and appoint another farm adviser. In the first instance a public hearing was held to determine whether the farm adviser was satisfactory to the Farm Bureau members. The hearing indicated that the farm adviser was eminently satisfactory, and the supervisors not only accepted the verdict of the people but have since made an appropriation for an assistant farm adviser. In other words, the policy is to remove the farm adviser from a county if after a thorough *public* investigation he is found not to be serving the best interests of the county as determined by the farmers themselves.

There are inherent reasons why the legislative or appropriating power should be separate from the appointing and executive power, as is the case in the federal and state governments but which has not heretofore been the case in county governments. For example, the

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farm adviser, acting under instructions of the federal and state agency, may be advocating cover crops, while a member of the board of supervisors in that county may be a fertilizer agent who feels that his business is not promoted by such advice. A supervisor may be a real estate agent. The farm adviser in the pursuit of his duty may pass adversely on a tract of land so far as it relates to the needs of a particular individual. A Farm Bureau may embark upon some policy such as pooling cream, which is contrary to the business interests of some relative of the supervisor. The board of supervisors may be supporting a chamber of commerce whose interests are not identical with those of the members of the Farm Bureau. All such points of contact are possible elements of friction and misunderstanding.

It is obvious that such conditions cannot be permitted to determine the appointment or continuance of a farm adviser. One of the most important facts concerning a farm adviser is that he represents an agency which does not try to direct or control the actions of any person and whose duty under the law is to discover the truth and disseminate it. It is essential that the farm adviser's position and his promotion shall depend upon the efficiency with which he carries out the purposes of this agency.

THE COUNTY HORTICULTURAL COMMISSIONERS

When the Farm Bureau system was introduced into California there already existed the county horticultural commissioner, who was performing, often with a considerable degree of efficiency, a portion of the work now done by the farm adviser. It is, in fact, to the credit of California that it had, in a measure, anticipated the coming of the farm-adviser system. It had been meeting its own needs in a local way as far as it could for many years before federal legislation instituted the nation-wide movement on a definitely organized basis. The county horticultural commissioner was the pioneer farm adviser, perhaps more accurately the pioneer horticultural adviser, and as such has done excellent service.

The legal duty of the county horticultural commissioner was and is the enforcement of the so-called horticultural laws of the state and the enforcement of the ordinances of the several counties relating to the control of insect pests, fungus diseases, rodents and weeds. Nevertheless, many of the horticultural commissioners have in the past found that they could serve the fruit growers more effectively by giving them advice than by performing police duties only. Indeed, such information often prevented the necessity for any legal action.

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Furthermore, in many counties where fruit is not a leading industry there were few occasions for inspection duties or for legal action.[1]

The horticultural commissioner, being employed upon a per-diem basis, found it expedient to employ his time as an adviser. These officers were, and still are, probably of greater service as expert advisers concerning the control of insects, fungus diseases, and related matters, than in the performance of their police duties. Although there have been some notable exceptions, the farm adviser has therefore been looked upon generally as an intruder, for two reasons: first, the county horticultural commissioner, for reasons stated above, felt he had a prior right to perform these functions. Second, the fear, perhaps not without justification in some counties, that his income would be reduced. There are many instances where these two representatives have worked together harmoniously to the manifest advantage of each other and the welfare of the county, as should, of course, be the case.

In some instances, however, the county horticultural commissioners have definitely protested against the farm adviser's giving information concerning horticultural matters. However, the United States Department of Agriculture and the College of Agriculture have no option in this matter. These agencies are specially required by federal law to give information on any subject which their investigations make them competent to furnish. It is obviously in the interests of the public welfare that it should be so. The basic purpose of the farm adviser is to make effective the researches of the United States Department of Agriculture and of the several state experiment stations.

On the other hand, the college of agriculture or agricultural experi-

[1] This discussion was submitted to Mr. G. H. Hecke, State Commissioner of Horticulture, who after offering certain suggestions has given it his hearty approval. He says: "The new amendments to the Horticultural Code of California have already taken into consideration the fact that the coming of the farm adviser makes necessary a clearly defined division line between his duties and those of the county horticultural commissioner, and . . . is based upon the acknowledgment of the fact that the farm adviser is serving his county as a representative of a research and educational institution, while the county commissioner will confine his work to the police duties connected with his office and the office of the State Commission of Horticulture. The addition to the California Horticultural Code placing county horticultural commissioners in charge of the control of weeds and rodents, as well as the carrying out of fruit standardization, is a big step toward avoiding future complications between these two county officials. I am sure that the control of weeds and rodents opens up big avenues of activity to the county commissioner, which will give him plenty of work, and will have a tendency to avoid an overlapping of the duties of these two omcials. I have not lost any chance or opportunity of calling the attention of the county commissioners to this fact, and they understand that, while formerly the county horticultural commissioner filled a dual rôle as police officer and as adviser, in the future we expect his duties to be so extensive that, as the farm adviser movement spreads, he will confine himself more and more to police work, as specified in the new amendments to the horticultural code."

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ment station is not charged by law with the performance of police functions except in certain cases, and cannot therefore perform such duties except in these specified instances. It is quite certain that it is not in the interest of public welfare that it should be charged with any police duties. The execution of the laws of the state is the duty of the executive branch of the state, with the governor as its head, who executes the laws relating to agriculture through such officers as state commissioner of horticulture and the state veterinarian. The functions of the university, and hence of the college of agriculture, are research and education. It cannot be repeated too often that the college does not seek to control the action of any person. Its primary function is to determine the truth and to state it accurately.

Because the legal duties of the county horticultural commissioner were rather inconsequential in some of the less populated counties, the county supervisors have sought to combine the work of the horticultural commissioner with that of the farm adviser and thus save the expense of one of these officers[2]. It would probably not be legal for one man to occupy these two offices, but in such a case he would, as county horticultural commissioner, be responsible to the county board of supervisors, and as farm adviser, he would be responsible to the College of Agriculture of the University of California. It has not been deemed wise to permit such an arrangement.

The reason lies deeper than the obvious administrative difficulties. It lies in the fact that the usefulness of the farm adviser as such would be greatly lessened by putting him in the wrong attitude towards the persons whom he is required to serve. This point of view is a little difficult to comprehend at first because the farm adviser is a new type of employee. He is so novel that there has been great difficulty in finding an appropriate name for him. He is not the agent of the executive branch of the government, but the representative of a research and educational institution. He possesses no executive or legal power, but he serves an organization of farmers known as the County Farm Bureau. Through it he serves all the citizens of the county who are seeking to create wealth out of the soil. He is able to serve them not only through his own knowledge of the science and practice of farming but because he has behind him in the United

[2] The State Commissioner of Horticulture writes: "The duty of controlling weeds and rodents will make the office of Commissioner of Horticulture of sufficient economic importance to justify a reasonable per-diem salary, even if the county is less populated and perhaps insignificant in the line of horticultural production," and adds: "I entirely share your view as to the inadvisability of having two offices, the one of farm adviser and the other that of county horticulture commissioner, occupied by the same man. It would create serious administrative difficulties."

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States Department of Agriculture and in the college of agriculture of his state a body of specialists whose investigations make them competent to give accurate information.

The County Farm Bureau, which is equally as important as the farm adviser, can do many things the farm adviser can not do. The farm adviser does not direct the Farm Bureau, but gives it the benefit of his advice. There is a possibility that the County Farm Bureau might embark upon some plan in which the farm adviser does not concur. However, thus far this has not been found an important practical difficulty.

The maintenance of both the county horticultural commissioner and the farm adviser is doubtless financially difficult for a number of the counties of the state. This fact probably justifies frank discussion of the relations of these two organizations and their future development.

The county supervisors are required by state law to appoint the county horticultural commissioner whenever a petition requesting his appointment is signed by twenty-five or more persons, each of whom is a resident, freeholder, and possessor of an orchard or greenhouse, or nursery, or rice field. The law provides that the compensation of the county horticultural commissioner shall be either not less than eighteen hundred dollars per year, or not less than six dollars per day when he is actually engaged in the performance of his duties. The salary of the deputy horticultural commissioners is five dollars per day, and the salary of inspectors three dollars and fifty cents per day.

The state law under which county supervisors are permitted to co-operate with the United States Department of Agriculture and the College of Agriculture is as follows:

"An Act (Laws of 1915, Chapter No. 373, signed May 18, 1915) empowering County Boards of Supervisors to appropriate and use county funds for the support and maintenance of Extension Work in Agriculture and the University of California. The people of the State of California do enact as follows:

"SECTION 1.—The Boards of Supervisors of the respective counties within the State are hereby empowered to appropriate and use county funds in not to exceed the amount of ten thousand dollars for any one year for the support and maintenance within their respective counties of extension work in agriculture under approval of the United States Department of Agriculture and in co-operation with the University of California."

Before placing the farm adviser in any county it is the policy, although not the law, to require at least one-fifth of the farmers to organize and join a Farm Bureau, to which each member pays one dollar annually to indicate his interest in the enterprise. This money is paid to and spent by the Farm Bureau. The County Farm Bureau

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is managed by a board of directors—one member from each community in the county and four members elected at large, together with a president, vice-president, and secretary-treasurer. The units of a Farm Bureau are known as Farm Bureau Centers, there being not more than thirteen in any one county. These centers have regular local organization and hold meetings once a month. The farm adviser travels on a regular circuit among these centers, completing the trip once each month.

This organization being completed, representatives of the Farm Bureau request the supervisors to appropriate two thousand dollars annually for three years for the expenses of each farm adviser and one thousand dollars annually for the expenses of each assistant farm adviser permanently located within the county. The college maintains certain other itinerant assistants who go from county to county to take care of the "peak load," to whom it pays all expenses in addition to their salaries. The United States Department of Agriculture and the College of Agriculture of the University of California pay the salaries of all advisers and assistant farm advisers. Speaking generally, a farm adviser is available for each county in California having, in 1910, 500 farms, and a permanent assistant farm adviser for every 1500 farms in addition to the first 1500 farms.

It will thus be seen that in case twenty-five fruit-growers sign a petition requesting it, the county board of supervisors must maintain a county horticultural commissioner, while they may contribute the expenses of the farm adviser in case one-fifth of the farmers in the county have joined the Farm Bureau and paid an annual due of one dollar. The reason for the law requiring supervisors to appoint county horticultural commissioners grows out of the fact that in the absence of suitable authority vested in the State Commissioner of Horticulture, the appointment of a county official is needed to protect a county from the possible introduction of plant pests from other states. In addition to this appointment by the supervisors with salary and expenses, the county commissioner is appointed by the state commissioner to serve the state as quarantine guardian without pay, and in the inspection of incoming plant material from outside the state he is acting directly as his representative. Under the fresh fruit standardization act and the apple standardization act he is also acting under direction of the State Horticultural Commissioner.

The county horticultural commissioner performs three classes of duties:

1. He inspects as quarantine guardian plants shipped to California from other states. Under present regulations such shipments go

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directly to their destination and are inspected by the horticultural commissioner or his deputy, often under difficult circumstances. In many cases to make an absolute diagnosis without serious injury to the shipment is well nigh impossible. This could be more efficiently done if the examinations were made at a few points of entry by agents delegated by the State Commissioner of Horticulture. Only a few men would be required for this work. They would soon come to have special expertness for it. It would be possible to provide proper depots so that materials could be inspected without injury and the plants fumigated or otherwise treated as occasion requires. If the proper legal relations existed between the State Commissioner of Horticulture and the county horticultural commissioner, the state commissioner could delegate certain county horticultural commissioners to perform this work.

2. The county horticultural commissioner is now charged with the enforcement of quarantines between counties in accordance with county ordinances. Recent legislation enacted at the request of the State Commissioner of Horticulture happily place the power of quarantining certain counties or districts exclusively within his authority.

3. The county horticultural commissioner is charged with the enforcement of certain state laws, but more particularly with that of county ordinances which the supervisors have adopted.

If the first two of these functions were placed in the hands of the State Commissioner of Horticulture, as the public welfare demands, then the question of whether or not the county should appoint men to enforce the laws and ordinances of local application may well be left to the county boards of supervisors. Without doubt a considerable number of counties in California need the services of such an officer.

Attention should be again called to the tri-party arrangement of the United States, state, and county in the case of the Farm Bureau system. Exactly the same reason exists for such an arrangement with reference to police regulations. The federal government already maintains quarantine officers in this state to inspect plants entering from foreign countries, and there exists a co-operative arrangement between the United States Department of Agriculture and the State Commissioner of Horticulture by which the same officers serve the purpose of both nation and state. The federal laws are sufficient to enable a federal officer to overrule either the work of the state or of the county horticultural commissioner in so far as relates to shipments of plants between states, or between counties. The way to avoid a possible clash as well as duplication of effort is to plan and put into operation a working arrangement between the federal, state, and county officers.

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It is the one way to insure the efficiency and permanency of these three sets of officers and incidentally remove all excuses for friction which now occasionally arise between the county horticultural commissioner and the farm adviser.

STUDENT ATTENDANCE

From an industrial point of view this country has been engaged in the war since August, 1914. These new conditions have been reflected in the attendance at the colleges of agriculture in this country. For example, of the 637 students in the College of Agriculture of this University in 1915–16, 108 received degrees. Of the 529 remaining, 176, or 33 per cent, failed to return to college during the first semester of 1916–17. There were 314 farm school students at the University Farm during the year 1915–16, of which 63 graduated, while the 122, or 48 per cent, remaining, failed to return to the school during the first semester of this school year. Whether similar analyses have been made in other colleges is not known, but a study of the entering freshmen in many of the colleges shows that with few exceptions there has been a lessening attendance.

Reference in the last annual report was made to the fact that only 32 per cent of the students of the College of Agriculture came directly from farm homes. There is some reason to believe that the falling off in students has been chiefly from the cities, due on the one hand to greater industrial activities in the cities, which have readily absorbed them, and on the other hand, to the greater interest created thereby in commerce and mining engineering. It is believed that the interest on the part of farm-bred men is on the increase rather than otherwise.

The total enrollment of University students in the College of Agriculture for 1916–17 was 623 as compared with 637 for 1915–16. At the University Farm School it was 314, being the same as for 1915–16. There was greater activity than ever in the Farmers' Short Courses. There were 197 persons registered, compared with 181 in corresponding courses last year. The new course in farm tractors caused an additional enrollment of 53, making a total enrollment of 250 in these short courses.

Thus the total enrollment of residence instruction in agriculture for 1916–17 was 1187, compared with 1132 in 1915–16.

The interest in the correspondence courses in agriculture continues to be well maintained. During the year ending April 30th, 1917, 6248 persons registered for the twenty-five courses in agriculture. Previously 23,374 had registered, making a total registration to date

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of 29,662. However, 8137 re-enrollments bring the total up to 37,759. During the year 3780 students completed one or more courses.

SPECIAL FORMS OF INSTRUCTION

The College of Agriculture has been developing brief courses of instruction to meet special interests. For example, the last week in December a course for veterinary practitioners was held at the University Farm School, with an attendance of 79 veterinarians. During the first week in January the wool growers had a convention at the University Farm, while in February the Berkshire swine breeders had a meeting and sale. The Citrus Experiment Station held a citrus growers' institute at Riverside in November, with an attendance of over 500. Two poultry short courses, one at Pomona and one at Van Nuys, were held in June, with a total attendance of 470 persons.

The Farm School Picnic, which has grown into a great farmers' field day, occurred this year on April 28th, with an approximate attendance of 14,500 persons. It was more educational than heretofore, and was a credit to the organizing ability and enthusiasm of the students, who are chiefly responsible for its conduct and success.

The College of Agriculture has farm advisers in eighteen counties, in which 218 farm bureau centers are organized, with a membership of about 6000 farmers. Certain allotments of funds from the Secretary of Agriculture will make it possible to extend this system rapidly in the near future.

The boys' agricultural clubs have been organized in more than one hundred high schools, with an average of about ten boys to a club, in which each boy is competing for a prize on the basis of net profit. Every two weeks during the period of this contest each of the boys receives written material for study concerning the crop or animal which he is raising.

As soon as it became evident that the boys' club movement in the high schools was succeeding, the college was strongly urged to extend the movement to the grammar schools. It has now made arrangements with fifteen boards of education by which in each of fifteen high schools an agriculturally trained teacher of agriculture will spend eleven months in the year at his work and will supervise boys' club contests in the grammar schools. Directly or indirectly the College of Agriculture, therefore, is coming in contact with boys between the ages of 10 to 14, with young men between the ages of 15 to 18, and with mature farmers. So far as they attend the college, either at Berkeley or Davis, the college also reaches young men between the ages of 18 and 23.

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If all young men who intended to engage in farming came to college for instruction the present system would suffice. They do not, however; neither do they attend the farm bureau meetings, because these meetings are conducted by and are of chief interest to more mature people. The experiment is now proposed of establishing junior farm-bureau meetings composed of young men who are definitely out of public schools but who are not yet ready to take part in the farm-bureau meetings composed of older people. Thus, when this plan comes into full operation there will be a method of reaching all the mature farmers of the state and all boys 10 years of age and over, who desire to engage in agriculture.

This whole problem will be further influenced by the passage of the federal Smith-Hughes Act, one section of which provides money to be used for salaries of teachers in agriculture who shall spend at least one-half of the time in actual instruction on a farm. The administration of that act in the several states is through the state boards of education acting under the approval of a federal board.

BULLETINS AND CIRCULARS

During the year there have been published eleven Bulletins and fourteen Circulars, in addition to the Director's Annual Report, the Prospectus of the College of Agriculture for 1917–19, the Announcement of Courses in Forestry for 1916–17, the Farmers' Short Courses, September 24th to November 2nd, 1917, and fourteen special leaflets on food conservation. Altogether, 1,165,000 copies have been printed, of which approximately 900,000 have been distributed. The mailing list has increased from 31,000 to 35,800 addresses.

BULLETINS

Bul. 270. A Comparison of Annual Cropping, Biennial Cropping, and Green Manures on the Yield of Wheat. B. A. Madson.

Bul. 271. Feeding Dairy Calves in California. F. W. Woll and E. C. Voorhies.

Bul. 272. Commercial Fertilizers. P. L. Hibbard.

Bul. 273. Preliminary Report on Kearney Vineyard Experimental Drain, Fresno County, California. W. W. Weir.

Bul. 274. The Common Honey Bee as an Agent in Prune Pollination. A. H. Hendrickson.

Bul. 275. The Cultivation of Belladonna in California. Albert Schneider.

Bul. 276. The Pomegranate. R. W. Hodgson.

Bul. 277. Sudan Grass. B. A. Madson and P. B. Kennedy.

Bul. 278. Grain Sorghums. B. A. Madson.

Bul. 279. Irrigation of Rice in California. R. D. Robertson.

Bul. 280. The Economic Irrigation of Alfalfa in Sacramento Valley. S. H. Beckett and R. D. Robertson.

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CIRCULARS

Cir. 152. Some Observations on the Bulk Handling of Grain for California. B. H. Crocheron and C. J. Williams.

Cir. 153. Announcement of the California State Dairy Cow Competition, 1916–18. F. W. Woll.

Cir. 154. Irrigation Practice in Growing Small Fruits in California. W. A. Hutchins.

Cir. 155. Bovine Tuberculosis. C. M. Haring.

Cir. 156. How to Operate an Incubator. J. E. Dougherty.

Cir. 157. Control of Pear Scab. R. E. Smith.

Cir. 158. Home and Farm Canning. W. V. Cruess.

Cir. 159. Agriculture in the Imperial Valley. A Manual for Settlers. W. E. Packard.

Cir. 160. Lettuce Growing in California. S. S. Rogers.

Cir. 161. Potatoes in California. J. W. Gilmore.

Cir. 162. Bacillary White Diarrhoea or Fatal Septicemia of Chicks and Coccidiosis or Coccidial Enteritis of Chicks. J. R. Beach.

Cir. 163. Some Fundamental Considerations Affecting the Food Supply of the United States. Memorandum Prepared for the Committee on Resources and Food Supply of the State Council of Defense. Thomas Forsyth Hunt.

Cir. 164. Small Fruit Culture in California. A. H. Hendrickson.

Cir. 165. Fundamentals of Sugar Beet Culture under California Conditions. R. L. Adams.

UNNUMBERED LEAFLETS

Observations on the Recent Agricultural Inquiry in California. Thomas Forsyth Hunt.

Canning Fruit in Glass Jars or Wax Top Cans. Frederic T. Bioletti and William V. Cruess.

Canning Fruits without Sugar. Division of Viticulture.

Canning of Fruit and Vegetables. Frederic T. Bioletti and William V. Cruess.

Canning Vegetables in Jars and Wax Top Cans. Frederic T. Bioletti and William V. Cruess.

Drying Winter Vegetables. Division of Viticulture.

Fruit Juices. Frederic T. Bioletti and William V. Cruess.

Jelly Stocks. Frederic T. Bioletti and William V. Cruess.

Living Expenses. M. E. Jaffa.

Preservation of Fresh Eggs. Division of Viticulture.

Preservation of Vegetables by Salt and Fermentation. Division of Viticulture.

Poultry as a Means of Conserving the Food Supply. J. E. Dougherty.

Growing Vegetables under Contract. Stanley S. Rogers.

The Farm Labor Situation in California. R. L. Adams.

NEW PROJECTS

The new projects outlined during the year are as follows:

No. 457. Relation of Oidium to the Keeping Qualities of Shipping Grapes. By F. C. H. Flossfeder reporting to F. T. Bioletti. At University Farm, Davis. Begun August 7. 1916.

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No. 458. Orchard Soils Investigations. A Test of Mulches for Orchard Trees. W. L. Howard. Begun August 8, 1916.

No. 459. Orchard Soils Investigations. Effect of Tillage Practices on Soil Moisture Content and Growth of Trees. W. L. Howard. Begun August 8, 1916.

No. 460. Wool Investigations; Growth and Shrinkage of Six and Twelve Months Wool. Robert F. Miller reporting to Gordon H. True. At University Farm, Davis. Begun August 8, 1916.

No. 461. Miscellaneous Projects. W. W. Weir reporting to C. F. Shaw.

No. 462. The Cost of Pork Production when Grain is fed in Conjunction with Alfalfa Pasture. J. I. Thompson and E. C. Voorhies reporting to Gordon H. True. At University Farm, Davis. Begun August 21, 1916.

No. 463. Investigations to determine Causes of Spotted Growth in Barley Fields. C. B. Lipman and J. W. Gilmore. Laboratories in Berkeley. Begun September 14, 1916.

No. 464. Flax Investigations. B. A. Madson reporting to J. W. Gilmore. At University Farm, Davis. Begun September 14, 1916.

No. 465. The Rancher's Home Garden. S. S. Rogers. At University Farm, Davis.

No. 466. Fattening and Marketing Old Ewes. R. F. Miller reporting to G. H. True. At University Farm, Davis. Begun September 23, 1916.

No. 467. Demonstration of Method of Growing Raisin Grapes. S. P. Frissell and A. E. Way reporting to F. T. Bioletti. At Kearney Vineyard. Begun November 7, 1916.

No. 468. Potato Improvement by the Hill Selection and Tuber-unit Method to Determine its Practicability for the Truck Grower. S. S. Rogers and E. B. Babcock. At University Farm, Davis. Begun May 29, 1917.

No. 469. Table Grapes for the San Joaquin Valley. A. E. Way reporting to F. T. Bioletti. At Kearney Vineyard.

No. 470. Pollination Studies. Staff of Division of Pomology reporting to W. L. Howard. At University Farm, Davis, laboratories in Berkeley and orchards of the State. Begun November 24, 1916.

No. 471. Fruit-bud Formation and Development. Staff of the Division of Pomology reporting to W. L. Howard. At University Farm, Davis, laboratories in Berkeley and orchards of the State. Begun November 24, 1916.

No. 472. Studies in Dairy Production by High-Producing Cows. F. W. Woll and Miss Cora J. Hill reporting to G. H. True. At University Farm, Davis. Begun December 6, 1916.

No. 473. Whole vs. Ground Grains as Feeds for Young Dairy Calves. F. W. Woll and E. C. Voorhies reporting to G. H. True. At University Farm, Davis.

No. 474. Investigations of the Efficiency of the "Calf-Way" Milking Machine. F. W. Woll reporting to G. H. True. At University Farm, Davis.

No. 475. Preparation of Volume Tables for Principal California Species. D. Bruce reporting to Walter Mulford. Chiefly in Berkeley.

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No. 476. The Development of a Practicable Dendrometer. D. Bruce reporting to Walter Mulford. In Berkeley. Completed.

No. 477. Cover Crop Breeding. L. D. Batchelor reporting to H. J. Webber. At Citrus Experiment Station, Riverside.

No. 478. Miscellaneous Drainage Investigations. W. W. Weir reporting to C. F. Shaw. Portions of State needing drainage.

No. 479. Soil Survey of Santa Maria Area. E. B. Watson (U. S. D. A.) and A. Smith reporting to C. F. Shaw.

No. 480. Reconnaissance Soil Survey of Southern California Area. Portions of Los Angeles, San Bernardino, Riverside, Orange, San Diego Counties. L. C. Holmes (U. S. D. A.) and others reporting to C. F. Shaw.

No. 481. Soil Survey of Ventura Area. J. W. Nelson and others reporting to C. F. Shaw.

No. 482. The Use of Pepsin as a Substitute for Rennet in the Manufacture of California (Granular) and Cheddar Cheese. H. S. Baird reporting to C. L. Roadhouse. Begun December 29, 1916.

No. 483. Is a Given Soil Type in Different and Far Separated Regions of California of the Same Nature in all Respects? Robert Pendleton reporting to C. B. Lipman. At laboratories and greenhouses in Berkeley.

No. 484. To Determine the Relative Value of Milo in Different Forms for Pork Production. J. I. Thompson reporting to G. H. True. At University Farm, Davis.

No. 485. Skim Milk vs. Whey in Pork Production. J. I. Thompson reporting to Gordon H. True. At University Farm, Davis.

No. 486. A Study of the Thermal Death Point of Bacillus botulinus, especially in Relation to the Sterilization of Canned Vegetables. W. V. Cruess in co-operation with the State Board of Health, reporting to F. T. Bioletti.

No. 487. Prune Studies. Staff of Pomology. Begun March, 1917.

No. 488. The Cumulative Effect of Cropping. G. R. Stewart and others reporting to J. S. Burd.

No. 489. A Detailed Study of the Effect of the Barley Plant on the Soil Solution. D. R. Hoagland and G. R. Stewart reporting to J. S. Burd. At Berkeley.

No. 490. Study of the Relation of the Concentration of Nutrient Solutions to the Growth of the Barley Plant in Sand and Water Cultures. The Relation of Solution to Absorption and Forms of Combination of Important Elements. D. R. Hoagland reporting to J. S. Burd.

No. 491. Studies in Soil Moisture. E. E. Thomas reporting to W. P. Kelley. At Whittier, California.

No. 492. The Fruit Bark Beetle. H. J. Quayle, A. F. Swain, reporting to H. J. Quayle, Riverside, California.

No. 493. A Synopsis of the Aphididae of California. A. F. Swain reporting to H. J. Quayle, Riverside, California.

No. 494. Manufacture of Concrete Irrigation Pipe. S. H. Beckett and Roy Wray reporting to Frank Adams. At University Farm, Davis.

No. 495. Studies in Adaptability and rate of Growth of Trees at the Santa Monica Forestry Station. W. Metcalf reporting to W. Mulford. At Santa Monica Forestry Station. Begun March 21, 1917.

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No. 496. Studies in Adaptability and Rate of Growth of Trees at the Chico Forestry Station. W. Metcalf reporting to W. Mulford at Chico Forestry Station.

No. 497. Methods and Cost of Distributing Milk with Special Reference to Oakland, Alameda and Berkeley. E. Mead.

No. 498. Survey of Proposed Bishop Drainage District. W. W. Weir reporting to C. F. Shaw.

No. 499. Grape Syrup as a Substitute for Sugar in Canning. Division of Viticulture reporting to F. T. Bioletti. At Berkeley, Davis and various canneries.

No. 500. A Survey of Utilization of Garbage for feeding Swine in California. F. M. Hayes and P. T. Petersen reporting to C. M. Haring.

No. 501. Increasing the Lamb Crop on the Range. G. H. True and R. F. Miller reporting to G. H. True.

No. 502. Investigation to find the Relative Value of Wheat, Hulled Rice and Paddy Rice as Grain Feed and of Wheat Shorts vs. Rice Polish in Mash for Laying Hens. By J. E. Dougherty. At University Farm.

No. 503. Study of Adaptability and Availability of Wood for Treenails. By M. B. Pratt reporting to W. Mulford.

No. 504. Canning and Preserving Fruit Without Sugar. W. V. Cruess reporting to F. T. Bioletti.

No. 505. Economical Drying of Wine and Table Grapes. F. C. H. Flossfeder and A. E. Way reporting to F. T. Bioletti.

No. 506. A Study of the Manufacture of Cheese and Whey. By H. S. Baird. University Farm, Davis.

No. 507. Drying Vegetables. Division of Viticulture reporting to F. T. Bioletti.

No. 508. Home Drying of Fruit. W. V. Cruess and F. C. H. Flossfeder reporting to F. T. Bioletti.

No. 509. Preservation of Vegetables with Salt. By W. V. Cruess reporting to F. T. Bioletti.

No. 510. Entomological Field Work. E. R. DeOng reporting to C. W. Woodworth. At University Farm.

No. 511. Preservative Treatment for Wood Silos. By J. B. Davidson and H. L. Belton reporting to J. B. Davidson. At University Farm, Davis.

No. 512. Reconnaissance Soil Survey of the Upper San Joaquin Valley. By J. W. Nelson and E. C. Eckmann reporting to C. F. Shaw.

There are submitted herewith a series of reports covering the activities of the Division of Agricultural Extension, together with several discussions growing out of the agricultural inquiry made by direction of the Committee on Resources and Food Supply of the State Council of Defense, as follows:

The Field Work of the College of Agriculture. Warren T. Clarke.

General Summary of Farm Adviser and Farm Bureau Work in 1916. B. H. Crocheron.

Agriculture Clubs in California. B. H. Crocheron.

The Agricultural Inquiry. David N. Morgan.

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Observations on the Recent Agricultural Inquiry in California. Thomas Forsyth Hunt.

Summary of the Reports of the Field Parties conducting Agricultural Inquiry, April 16–27, 1917.

I. Southern California. L. D. Batchelor.
II. Central Counties. B. H. Crocheron.
III. South Coast Counties. W. T. Clarke.
IV. Inyo County. V. C. Bryant.
V. Eastern Counties. W. L. Howard.
VI. North Coast Counties. T. Francis Hunt.
VII. North Central Counties. H. E. Van Norman.
VIII. Northeastern Counties. G. H. True.
Irrigation Survey. Elwood Mead and Frank Adams.

Ever since the United States was declared to be in a state of war, the department by your instructions has considered it its first duty to serve the federal and state governments in promoting the increased production by field measures. This new activity has necessitated some change of direction and emphasis in the research work of the station.

On April 12, 1917, the members of the staff throughout the state were called into conference. A committee was appointed to classify the projects then in progress into those which should be continued and those which could be temporarily abandoned because of the emergency. Obviously certain projects must be kept going at all cost, since a break in the continuity of the work would be fatal. A committee was also appointed to procure suggestions from the divisions regarding emergency investigations to be undertaken, and to pass upon their relative importance. About a dozen emergency projects were started and eighteen other projects have been passed upon favorably and will be carried on as time and funds permit.

Very truly yours,

THOMAS F. HUNT.

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THE FIELD WORK OF THE COLLEGE OF AGRICULTURE

By W. T. Clarke

The work of the Division of Agricultural Extension has included land examinations, field demonstrations, extension schools, farmers' institutes, single lectures, running an agricultural demonstration train, exhibits at fairs and other shows, organization of women's clubs and special home economics demonstrations and lectures, county farm adviser and farm bureau work, and agricultural clubs in the schools.

During the past year the work has grown to such proportions that it has been necessary to put on certain Extension specialists to meet the demand. This demand for special work has come from both the counties that have county farm advisers and from the counties that do not have farm bureau organizations. These specialists have filled a long felt need in doing effective extension work and have been a valuable addition to the Division.

FARMERS' INSTITUTES

Farmers' institutes have been held in the counties which do not have county farm advisers insofar as the farmers have demanded these institutes and petitioned for the same. Twenty one-day institutes have been held in the various unorganized counties of the state and five two-day institutes, with a total attendance of 1843.

Farmers' institutes are not held in the counties where there are county farm advisers, and this, together with the fact that a large number of them have been replaced by field demonstrations and single special lectures, accounts for the fact that the number of institutes this year was not as great as in previous years. The farm advisers took part in 1902 meetings, including 1689 farm bureau meetings, with a total attendance of 94,306 persons.

SPECIAL INSTITUTES

During the past few years there has been a tendency for farmers' institutes to become more specialized, and growing out of this we gave during the past year a few special institutes where only one subject was discussed during the entire time. A notable example of this was the Fig Institute held at Fresno, January 12th and 13th. There was a total of five meetings where nothing was discussed except

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various phases of the fig industry. This meeting was attended by practically all the fig growers throughout the San Joaquin Valley. The average attendance at each meeting was approximately 350, making a total attendance of about 2000.

SINGLE LECTURES

During the past year there have been given by various members of the staff, under the auspices of this Division, 430 lectures, with a total attendance of 33,938. These are given largely in connection with various clubs, granges, and other local agricultural organizations. Some subject of special and timely interest is usually discussed at these lectures and the audience is also given an opportunity to ask questions along the lines of discussion. In this way they have considerable value in bringing before the people the services of the College of Agriculture and also in imparting specific information along the lines of the subject being discussed.

FIELD DEMONSTRATIONS

Following up the general policy of giving special work which is of timely interest, a great many field demonstrations have been given during the past year. These demonstrations use up from one-half day to a day's time. The usual form of giving demonstrations is for the demonstrator representing the College of Agriculture to give a short discussion in some building such as a school house, or often in the open field, and then proceed to give some special line of demonstration.

Demonstrations were given last year of latest methods of pruning vines, of all ages, pruning of all kinds of deciduous fruits, control of various insect pests and plant diseases, demonstrations of the control of hog cholera, selection of all kinds of live stock, and a great many farm home demonstrations, such as canning, drying of fruits, etc.

The total number of demonstrations during the past year was approximately 69, aggregating a total attendance of 3061.

MOVABLE SCHOOLS

In some localities there has been given during the past year a special Extension School along some special line of farming. These schools last from three to five days, holding from two to three sessions per day. These are modeled somewhat after a farmers' institute, but specialized to the extent of only studying one subject, together with its allied phases. They also consist of a great deal of demonstration work. These schools give the farmer of the locality an opportunity to get acquainted with the instructors and also gives the instructors an

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opportunity to get acquainted with the farmers' conditions, so that the chances for doing real service and imparting practical information is greater than where a single lecture or a single institute is held.

Owing to a limited number of workers and funds, only two of these schools were given during the past year, with an average daily attendance of 69, aggregating a total of 696.

FAIRS

During the past year various educational exhibits were prepared by the Extension Division showing the results of some of the investigational work of the Experiment Station and the educational work of the College of Agriculture. Five exhibits were prepared for state and county fairs and one permanent exhibit. Excepting the permanent exhibit these exhibits were all accompanied by specialists that presented certain lines of work that would be of special value to that particular locality. Judging the different agricultural exhibits, including livestock, was also a part of the work done at these and other fairs.

DEMONSTRATION TRAIN

During the month of May a special Agricultural Preparedness Train was run through the states of Utah, Nevada, and California, over the Los Angeles and Salt Lake Railroad. This train was a cooperative arrangement between the Utah Agricultural College and the Universities of Nevada and California, and the Los Angeles and Salt Lake Railroad. This station had two cars in the train, *i.e.*, a car of beans and a car of forage crops. The plan for operating this train was to spend one day in each town, keeping the train open each day and holding an evening meeting each evening. The total number of people passing through the train was 55,000. The total attendance at the evening meetings was 2949. This shows that the train was well attended and did very effective work.

LAND EXAMINATIONS

The Extension Division is constantly receiving requests to examine ranches. These requests come from varied sources—from the new settlers who are not familiar with California conditions, city people who want to go on the land, non-resident owners, and persons who desire help to "stop leaks" in ranches in operation. In doing this work the department has adopted the policy of gladly rendering service to anyone who is trying to make wealth from the soil. In order to facilitate the work the problem to be investigated should be presented to the Extension Office either in person, by mail, or by phone, in order

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that the advisability of examination, and the specialist from the office best adapted to do the particular piece of work in question may be determined. Problems are investigated and opinions given regarding agricultural questions, but valuations are not placed on properties for obvious reasons. Nor are differences arbitrated between buyers and sellers of property.

During the past year the Extension staff have examined a large number of properties, which vary in size from the five-acre suburban tract up to ranches of 5000 acres. The larger number of requests for examination are ranches of from 30 to 160 acres.

Three men on the staff are in a position to do this work, and each of the men has made on an average of from one to four examinations a week. During the last year more than 100,000 acres of land have been examined and reports given thereon. This does not include visits made to sections to investigate diseases, insect pests, and soil problems that may be prevalent in some particular section of the state.

FARM HOME MANAGEMENT PROJECT

Farm Home Lecture-Demonstrations.—The work in California during the fiscal year 1916–1917 has been directed chiefly to lecture-demonstration work in the conservation of farm home products. The records of this work show that 355 lectures and lecture-demonstrations have been given in more than three-fourths of the counties of the state, with a total attendance of 12,708 housekeepers. The records also show that 40 per cent of the lessons have been given on canning; 20 per cent on jelly making; 16 per cent on balanced rations; 11 per cent on salads; 7 per cent on left-overs. The remaining 6 per cent covers a variety of subjects suggested by special needs. Mimeographed copies of the recipes used in the lessons are sent to housekeepers upon request, besides the printed bulletins and circulars available.

The field service deals directly with the problem of living—how to get the most and best out of the products of the farm with the greatest economy of money, material, and labor. Instruction on the subject of conservation of farm products includes canning, preserving, pickling, jelly making, candied fruits, drying fruits, drying and salting vegetables, preserving of eggs, use of left-overs, etc. In canning, the work covers all the meat and poultry, fruit and vegetables produced on the farm. California housekeepers are now conserving for family use, beef, veal, pork, Belgian hare, chicken, turkey, duck, fish, squabs, and in soup, beef, veal, and turtle. To add a variety and increase the supply, combinations are made in the canning. In the fruit work

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wild and cultivated fruits are combined, giving a more satisfactory product than either used alone.

Extension Clubs for Farm Women.—There are at present 57 women's clubs in California directly in touch with the Extension Division of the College of Agriculture. Twenty-six of these Agricultural Extension Clubs are studying farm home problems by means of regular program study work. The total membership of these clubs is 595 farm women.

The object of these clubs is to study farm home problems; to develop leadership; to study and to use parliamentary law; to promote social life; to create and nourish community activities and civic pride; to form a stable support for Extension service. The main part of the year's program must relate to household subjects. Papers are read at each meeting of the club, followed by some discussion. When the club is not too far distant from Berkeley, six free lectures a year are given. These lectures include the lecture-demonstration work on conservation of farm products, balanced rations, kitchen equipment and kitchen methods, labor-saving devices, and farm sanitation. When these lectures are given an open meeting is held and the entire community is invited by the club. This organized group of workers banded together for mutual helpfulness furnishes a school where country women may receive Extension instruction. It is the connecting link between the country home and the Extension Division.

LETTERS

During the past year the Extension Division has written 28,162 letters, while the total number written by the staff of the College of Agriculture, not including the farm advisers, was 104,000. Most of these have been requests for information regarding some problem that has arisen in connection with some farming operation. For the most part these are inquiries of a specific nature and require a like answer. Two hundred and twenty-three letters were received from prospective settlers from outside of the state, seeking reliable information regarding farming conditions in this state. A great many inquiries were also received each week from people within the state who are considering going farming, seeking information regarding some particular locality or some particular line of farming. The handling of this correspondence, together with making out reports and sending out publications, required the maintenance of a large office force.

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GENERAL SUMMARY OF FARM ADVISER AND FARM BUREAU WORK IN 1916

By B. H. Crocheron

Organization.—In the fourteen farm adviser counties of California there are 5312 farmers who are Farm Bureau members and who co-operate with farm advisers in their work. One new county, Imperial, has been successful in completing this organization and securing the $2000 appropriation from the Board of Supervisors during 1916. One other county, San Luis Obispo, has completed its Farm Bureau organization with over the required number of members, but has been unable as yet to secure the necessary appropriation from the supervisors. During the past year, the chief development within the Farm Bureau has been the organization of departments which will undoubtedly prove of great value in that: (*a*) they combine in one organization all persons interested in all phases of agriculture, while at the same time they permit of the joining together of all those interested in one particular phase of agriculture; (*b*) they prevent the formation of other local agricultural organizations which would encroach on the work of the Farm Bureau and might even threaten its existence. Departments have been formed in the Farm Bureau counties of California as shown in the following summary:

Cow-testing departments	2
Cow-testing associations which may become departments	4
Dairyman's department (milk and cream weighing and testing)	1
Cream pooling departments	2
Swine breeders' associations	1
Poultry raisers' department	1
Purchasing and marketing department	1
Farm loan departments (several on way)	1

Projects.—The 104 separate projects which the farm advisers have started up to December 1, 1916, may be grouped into the following 13 general classes and 46 sub-classes:

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	No. of Counties
I. Rural economics:	
Highway tree planting	2
Telephone service extension	1
Electric power service extension	1
Rural road improvement	1
Control of storm waters	2
Brush burning on hillsides	1
Hill forestation	1
Total number	10
II. Farmers' organizations:	
Hog raisers' and swine breeders' association	3
Dairy, cow-testing and cream-pooling associations	8
Winter vegetable union	1
Lima bean growers' associations	2
Beemen's association	1
Total number	15
III. Boys' agricultural clubs:	
High school agricultural clubs	3
Elementary school agricultural clubs	3
Total number	6
IV. Agricultural fairs	1
V. Home economics	2
VI. Soil treatment:	
Subsoiling	1
Deep plowing	1
Prevention of erosion by terracing	1
Soil drainage	2
Fertilization	13
Liming of soils	4
Alkali reclamation	1
Cover crops	4
Total number	27
VII. Crop rotation	2
VIII. Animal husbandry:	
Dairy improvement	1
Hog cholera control	2
Pig management	1
Total number	4
IX. Forage crops:	
Sorghum	3
Alfalfa culture	2
Winter forage crops	1
Sweet clover	1
Total number	7

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	No. of Counties
X. Cereal and field crops:	
Rice	3
Australian wheat varieties	1
Barley culture	1
Bean culture	1
Total number	6
XI. Orchard and vineyard work:	
Pruning	4
Trellising grape vines	2
Tree record work	2
Orchard management	1
Total number	9
XII. Farm pest control:	
Spraying orchards and vineyards for insects and fungus diseases	4
Weed eradication	2
Squirrel and gopher extermination	5
Total number	11
XIII. Farm bureau:	
Legislative committee	1
Increasing attendance at center meetings	1
Assistant farm adviser's work	1
Directors' meeting program	1
Total number	4

Campaigns.—A number of very successful Farm Bureau campaigns for the control of various farm pests, diseases of animals, the improvement of rural conditions, etc., have been conducted during the year. Among these may be mentioned: Control of hog cholera, grasshopper pest, and rice weeds, squirrel destruction, formation of storm districts for the control of flood waters, installation of septic tanks on the farms, improvement of rural schools, and construction and use of silos.

Demonstrations.—Among the demonstrations of special interest are: The use of cover crops in orchards, the growing of Sudan grass, growing alfalfa on hillsides, growing of winter forage crops, the spraying of orchards for insect pests and fungus diseases, the best methods of pruning vines and fruit trees, the use of fertilizers on alfalfa land, the trellis pruning of seedless raisins, varieties of rice adapted to different localities, scientific cooking demonstrations.

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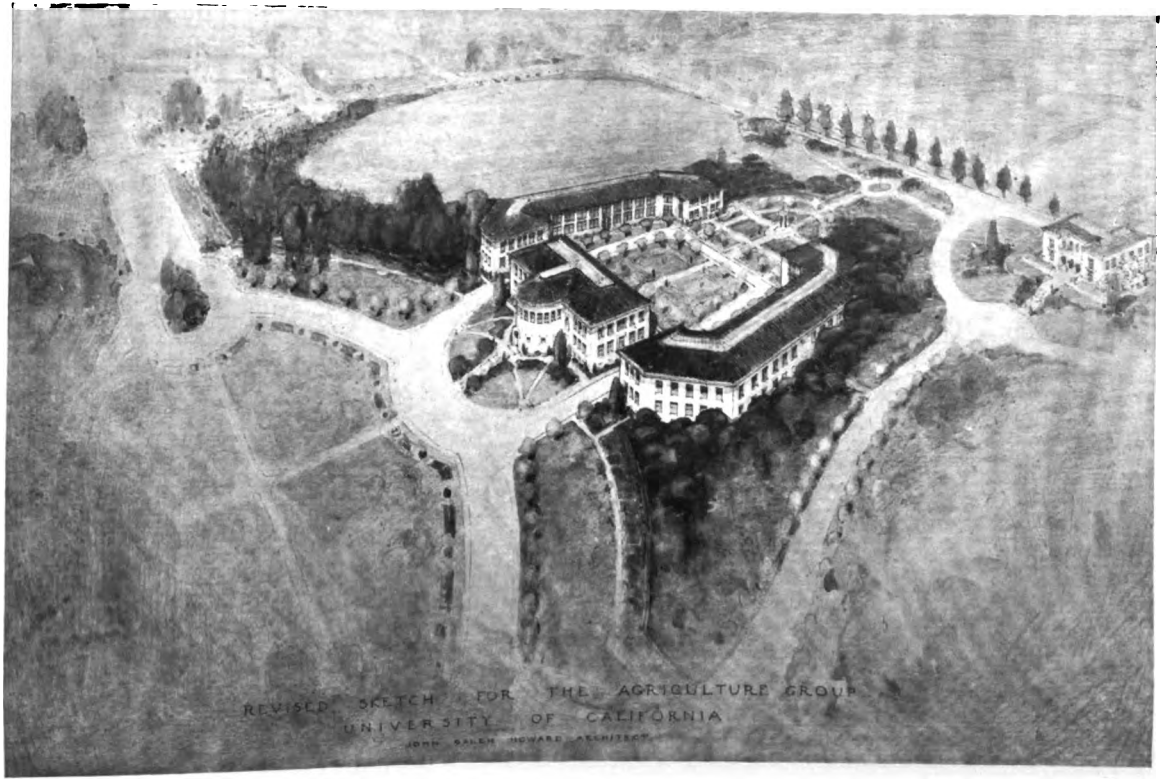

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Important Lines of Progress.—The most important lines of progress accomplished during 1916 were:

(*a*) The additional employment of assistant farm advisers, thereby relieving the farm advisers of the peak load which, for some seasons, they have been compelled to carry. The plan permits certain individuals to devote their whole time to a single project which needs special attention for its speedy accomplishment. It has also provided a force of young men selected for the purpose a definite training for farm adviser work.

(*b*) The completion of the project system of outlining work to be accomplished and in better office organization whereby this could be followed up.

(*c*) The increased organization of Farm Bureaus through their subsidiary departments, which united many interests under the one banner.

(*d*) Undoubtedly, also, a distinct line of progress has been in the bettering of the farm demonstrations and the distinct increase in their number during the past year. Experience indicates that several years are required before most men can become sufficiently well acquainted with the problems of their county to adequately demonstrate the solution of these to the farmers. It is among the longer established members of the force that the best demonstration work is being done, which leads us to conclude that in sufficient time, we will have it adequately worked out elsewhere.

STATE SUMMARY OF FOURTEEN FARM ADVISER COUNTIES FOR ELEVEN MONTHS

Different farmers visited on their farms	5,142
Total number farm visits made	9,157
Calls on farm adviser at office relating to his work	9,930
Meetings held under auspices of farm bureau	1,689
Total of all meetings in which farm adviser took part	1,902
Total attendance at such meetings	94,306
Membership in county farm bureaus	5,312
Boys' and girls' clubs organized in 1916 in farm adviser counties	40
Total membership in such clubs	437
Agricultural observation parties conducted	54
Total number persons in such parties	1,211
Farmers treating seed oats for smut	24
Acres of oats sown with treated seed	3,140
Farms on which farm adviser knows that alfalfa was sown, following his suggestions	213
Total acres of alfalfa so sown on above farms	1,771
Farms on which farm adviser knows that winter or hairy vetch was grown, following his suggestions	87

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Acres of winter or hairy vetch so grown	1,284
Orchards cared for in whole or in part on suggestion of farm adviser	573
Trees in orchards so cared for	309,736
Registered sires (all kinds) purchased	81
Registered cows purchased	78
Cow-testing associations organized	5
Cows tested for milk production through such associations	13,376
Animals tested for tuberculosis by farm adviser or on his suggestion	3,476
Animals vaccinated for blackleg by farm adviser or on his suggestion	4,219
Hogs vaccinated for cholera by farm adviser or on his suggestion	7,372
Silos constructed	94
Crop rotation systems planned and adopted	131
Drainage systems planned and adopted	50
Irrigation systems planned and adopted	30
Acres included in these drainage areas	14,220
Acres included in these irrigation areas	2,640
Farms using chemical fertilizers	56
Tons chemical fertilizer so used	262.75
Tons of lime or limestone used	5,389
Acres of clover and other legumes plowed under for green manure	2,880

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AGRICULTURE CLUBS IN CALIFORNIA

By B H. Crocheron

For four years agriculture clubs have been steadily organizing and working in California, until now there are 208 clubs in as many schools, with 2716 school boys and girls growing crops on farms under the direction of the University. The movement for agriculture clubs in California started on its present basis in January, 1914, with the students of the College of Agriculture, who, having an agriculture club of their own, felt that there were boys in the state too young to go to college, or who had missed the opportunity, but who would like to take part in growing contests with crops or animals and so demonstrate their ability to make money on the farm. With the aid and co-operation of the Extension Division, a committee of over forty students launched the campaign for agricultural clubs, which were at that time restricted to pupils of high-school age. The movement was then confined to secondary school boys, because: (1) they were less numerous than the vast army of elementary school boys and thus could be more adequately reached; (2) they were nearly of vocational age and therefore might be expected to respond to the money-making aim of the clubs; (3) they naturally looked up to the college students who were to be their volunteer leaders. From the first these clubs had a rapid growth. All during the long, hot summers hundreds of high-school boys demonstrated their ability and desire to grow crops on California soils.

The fundamental assumptions on which the agriculture clubs started were: (1) that the agricultural institutions of the state and nation had information which, applied to farming, would increase farm profits; (2) that many boys and some girls want to make money by farming and want to be shown how, and (3) that the chances for individual success are increased when several persons in the same neighborhood undertake the same work, an added interest for which comes through competition. Unless the above three assumptions are correct the idea of agriculture clubs in California is unsound.

All boys in any one club grow the same crop, but different clubs must grow different crops because of the highly divergent character of agriculture in the state. Twenty-four possible contests were

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planned, selection being left to the club on the basis which might be expected to result in the most monetary profit to that particular community. Gradually, through the experience gained, the contests selected have narrowed down to about a half dozen.

In the first year the boy seldom grows a crop of much profit, but by the second year lessons have been learned which, applied in the field, give larger profit. By the third year the boy begins to see that only by unusual care and attention can unusual yields be obtained. Boys then often conduct seed selection or even plant-breeding demonstrations in addition to their regular plot and often extend the area of these plots far beyond the acreage required by the contest until they become large field projects.

No prizes of any kind for club work are offered by the University. It is evident, however, that the work has the enthusiastic approval of the people of the state, since each year they have subscribed large prizes. The chief prize offered has been a trip to the University Farm at Davis. Thus in 1914, 143 boys were there in camp; in 1915 there were 250; and in 1916 almost 300. At Davis the boys camped out for three days in militia tents, were entertained by the college, and spent the time in receiving agricultural instruction. In 1915 the trip also included a visit to the Panama-Pacific Exposition in San Francisco, while in 1916 they journeyed by special train to Berkeley and the campus of the University. For three years the communities have sent a carload of the high-school prize winners of the agricultural clubs on a 9000-mile tour around the continent in order to study the various types of agriculture in America, as well as to see some of the big cities, industries and places of historic interest. The tour is definitely organized for agricultural instruction in order to train leaders for country life in California. Of course, no boy of the contest really "wins" or "earns" a transcontinental tour. It is an investment made by the people in the expectation that in later years he will give a return to the community far beyond the expenditure. More than anything else, country life needs leaders trained from among their own people. Some of these leaders in the future will come from the "Transcontinental Tour Boys."

From the beginning the intention has been to extend the agriculture clubs to the sixth, seventh, and eighth grades of the elementary schools as soon as the high-school development became fixed and as soon as sufficient trained supervision could be obtained. It has been found necessary for the success of agriculture club boys that they should be visited at least once a month on their home farms during

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the growing season in order to give them the encouragement and advice necessary to make their work a success, also to send them printed instructions and definite information on the crop they are growing at regular intervals of two weeks. While the University could furnish sufficient supervisors to oversee competently the work of the high-school boys, the problem of directing similar work in the elementary schools seemed too broad to be attempted.

But there are in California forty-nine high schools which employ instructors in agriculture, all trained men. Most of these are employed but nine or ten months a year. During the two or three months when farming operations are most active, these instructors are absent from their communities or remain there inactive in leadership. It was finally proposed to employ such instructors for three months in co-operation with the high-school boards. Where this is done the agricultural instructor from the high-school agrees to spend three months in agricultural extension activities in the district tributary to his high-school; the high-school board agrees to appropriate not less than two hundred dollars for expenses; the College of Agriculture, in co-operation with the United States Department of Agriculture, agrees to pay two hundred dollars salary for the work so done. In 1916, fifteen high-schools and their instructors entered into such an agreement. For 1917–18, it is proposed to extend the plan to forty-five such districts.

With the development of the high-school movement, the high-school club members became desirous of organizing elementary school clubs in the country roundabout and exercise volunteer supervision within their territory in the same fashion as earlier the University boys went out among the high schools. Napa County took the initiative in 1916 when boys from the Napa High School were placed in charge of rural elementary clubs conducted under their direction. This volunteer supervision acting under the direction of paid leadership has worked out successfully wherever tried.

The number of clubs organized in the high schools since the beginning of the work is as follows:

1914	343	1916	1157
1915	684	1917	1896

The number of boys enrolled in high-school clubs since the beginning of the work is as follows:

1914	37	1916	103
1915	71	1917	101

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To the 1917 figures should be added elementary agricultural club enrollment of 820 boys in 107 clubs in the 15 high-school districts, making 2716 who in 1917 are growing crops in agricultural clubs.

No such system of agricultural clubs has been devised by any other state. While the number of secondary school boys enrolled has been comparatively small, the plan has been so sound that a greater proportion of the boys complete the contests than elsewhere. In 1915, 82 per cent of the boys who enrolled in the contests successfully completed them and passed in reports of their work, while in 1916, 57 per cent so finished. The 1917 crop season is still in full swing, but it is evident that the principle involved will again demonstrate its value. This has been partly due to the close supervision which the agricultural clubs throughout California are given by the men employed for the purpose and to the enthusiasm and help of the students in the higher institution. We may confidently expect the extension of the scheme whereby, under the guise of clubs, California boys raise real crops on real farms.

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THE AGRICULTURAL INQUIRY

MADE BY DIRECTION OF THE COMMITTEE ON RESOURCES AND FOOD SUPPLY OF THE STATE COUNCIL OF DEFENSE

By David N. Morgan

At the first meeting of the State Council of Defense, held in Sacramento April 6th, 1917, a Committee on Resources and Food Supply was formed, with the following members:

Charles H. Bentley, San Francisco.
B. B. Meek, Oroville.
Miss Ethel Moore, Oakland.
John A. O'Connell, San Francisco.
Pres. Benj. Ide Wheeler, Chairman.

On April 10th, this committee held its first meeting in California Hall, University of California. Besides the members of the committee, there were present by invitation:

E. T. Ford, of W. R. Grace & Co., San Francisco.
S. P. Frisselle, Superintendent Kearney Ranch, Fresno.
G. H. Hecke, State Horticultural Commissioner.
Victor Henderson, Secretary Board of Regents and Secretary of the Committee.
Jas. Irvine, representing California Development Board.
Stoddard Jess, First National Bank, Los Angeles, Cal.
Dr. Chas. C. Keane, State Veterinarian, Sacramento.
H. S. Maddox, Secretary State Horticultural Commission.
S. B. McNear, Vice-President Sperry Flour Co.
J. M. Perry, President State Agricultural Society, Stockton.
G. H. Powell, Manager California Fruit Growers' Exchange, Los Angeles.
C. E. Rachford, U. S. Forest Service, San Francisco.
Dr. W. A. Sawyer, Secretary State Board of Health, Sacramento.
D. D. Waynick, representing Graduate Students, College of Agriculture.
Thomas Forsyth Hunt, Dean of the College of Agriculture.

And the following members of the faculty of the College of Agriculture:

Professors: W. T. Clarke, B. H. Crocheron, J. W. Gilmore, C. M. Haring, M. E. Jaffa, C. B. Lipman, E. Mead, D. N. Morgan, W. Mulford, W. E. Packard, C. F. Shaw, G. H. True, H. E. Van Norman, R. S. Vaile, H. J. Webber, and C. W. Woodworth.

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On motion of John A. O'Connell, it was voted to refer to the College of Agriculture the following topics for consideration:

1. Investigation of the normal requirements of the people of the state for food and the sources of supply.
2. The normal surplus of staples.
3. The facilities for holding reserves.
4. An estimate of the current crop.
5. Animal and sea foods.
6. Possible substitutes for food usually imported.
7. Conservation of food and elimination of waste.
8. The advisability of land-settlement legislation.

In securing these data the College of Agriculture was requested to co-operate with "The State Statistician, the State Horticultural Commission, State Market Director, and such other state, federal, and other agencies as Dean Hunt may find available." The U. S. Forest Service, the State Commission of Horticulture, the State Board of Health, State Veterinarian, State Market Director, the Sacramento Valley Development Board, and the California Fruit-Growers' Exchange were among the agencies that assisted in this work.

The Governor of California also issued the following proclamation, in which he asked the co-operation of all the citizens of the state:

Whereas, an emergency in our National and State affairs now exists in which it is desirable to have full information concerning the production, distribution and supply of food in the State of California; and

Whereas, the committee on resources and food supply of the State Council of Defense has directed the Department of Agriculture of the University of California, assisted by the State Department of Agriculture, State Department of Horticulture, Health, Veterinary, State Market Director, the United States Forestry Service and other agencies, to hold meetings in the various counties of the State, and to the end that the desired information may be expeditiously obtained.

Therefore, I, WILLIAM D. STEPHENS, Governor of California, do direct that such hearings be held and I call upon the producers and distributers of foodstuffs to set aside their usual occupations in order to attend the conferences at the places and dates between April 16th and 23rd already announced in the various counties.

In accordance with these instructions, eight parties were organized, with the personnel shown on page 45, which, between April 16th and 27th, held hearings in fifty-five counties in California. As the data were collected by the field parties they were mailed to the College of Agriculture, where they were tabulated and digested by a committee consisting of Professors John W. Gilmore, Elwood Mead, and the writer. Each field party prepared a special report on its particular district, which will be found on pages 72 to 95.

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On May 22nd, the Dean of the College of Agriculture made a report to the Committee on Resources and Food Supply on the broader aspects of the inquiry, which was ordered printed under the title, "Some Observations on the Recent Agricultural Inquiry in California," (p. 50).

As stated above, hearings were held in every county in this state except three. The members of the staff of the College of Agriculture conducted these hearings, being ably assisted by the State Commissioner of Horticulture and representatives of his office, and the offices of the State Veterinarian, State Board of Health, and the United States Forest Service.

Some federal or state officer in each county was charged with the responsibility of arranging for the meetings. In counties where farm advisers are employed, the farm advisers, with the assistance of their farm bureaus, made the necessary arrangements. In other agricultural counties the horticultural commissioners handled the arrangements in a gratifying manner. In the mountain counties the United States Forest supervisors ably performed this service.

The newspapers, telephone companies and theatres all co-operated in advertising the meetings. The plan called for a forenoon meeting of twelve farmers representative of the various districts of the county. These farmers met in a round-table conference, giving information to the visiting investigators. The subject matter for discussion at the afternoon meeting was decided upon.

There follows herewith answers given at these morning conferences to the twenty-two questions asked:

1. Crops: Per cent of normal acreage:

(*a*) *Alfalfa:*

Normal in Amador, Butte, Contra Costa, Eldorado, Lake, Los Angeles, Mono, Placer, Santa Cruz, Shasta, Sutter, Tuloumne, Yolo, and Yuba. Alameda, 110 per cent; Calaveras, 65; Colusa, 115; Fresno, 80; Glenn, 120; Imperial, 135; Inyo, 105; Kern, 75; Kings, 80; Lassen, 95; Madera, 80; Merced, 75; Modoc, 90; Monterey, 90; Nevada, 110; Riverside, 95; Sacramento, 85; San Bernardino, 80; San Diego, 108; San Joaquin, 90; Santa Clara, 85; Siskiyou, 105; Solano, 120; Stanislaus, 60; San Bernardino, 125; San Diego, 150.

(*b*) *Barley:*

Normal in Amador, Butte, Colusa, Eldorado, Imperial, Inyo, Kern, Modoc, Nevada, Plumas, San Joaquin, Shasta, Solano, Trinity. Alameda, 30 per cent; Calaveras, 95; Contra Costa, 30; Fresno, 25; Glenn, 130; Kings, 55; Lassen, 110; Madera, 48; Mariposa, 70; Mendocino, 110; Merced, 50; Monterey, 85; Orange, 65; Placer, 75; Sacramento, 115;

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San Luis Obispo, 105; Santa Clara, 50; Siskiyou, 103; Stanislaus, 90; Sutter, 115; Tehama, 110; Tulare, 35; Tuolumne, 50; Yolo, 125; Yuba, 115.

(*c*) *Oats:*

Normal in Amador, Butte, Fresno, Glenn, Inyo, Kern, Lassen, Modoc, Plumas, Shasta, Solano, Tehama, Trinity, Tuolumne, and Yuba. Calaveras, 85 per cent; Eldorado, 90; Imperial, 60; Los Angeles, 75; Madera, 48; Mariposa, 60; Merced, 85; Monterey, 110; Riverside, 50; San Bernardino, 125; San Diego, 150; San Joaquin, 80; Santa Clara, 50; Siskiyou, 110; Stanislaus, 80; Sutter, 90.

(*d*) *Wheat:*

Normal in Amador, Butte, Colusa, Imperial, Kern, Nevada, Plumas, Sacramento, Solano, Tuolumne, Yuba. Calaveras, 90 per cent; Eldorado, 50; Fresno, 20; Glenn, 120; Inyo, 120; Kings, 25; Lassen, 105; Los Angeles, 75; Madera, 48; Mariposa, 75; Modoc, 120; Monterey, 90; Placer, 90; Riverside, 50; San Bernardino, 125; San Diego, 150; San Joaquin, 120; San Luis Obispo, 115; Santa Clara, 50; Shasta, 110; Siskiyou, 105; Stanislaus, 120; Sutter, 80; Tehama, 80; Trinity, 105; Yolo, 75.

(*e*) *Rice:*

Butte, 110 per cent; Colusa, 136; Glenn, 190; Madera, 800; Fresno, 130; Sutter, 25; Yolo, 144; Yuba, 600.

(*f*) *Sugar beets:*

Normal in Kings, Monterey, Orange, San Diego, San Luis Obispo, Santa Barbara. Alameda, 130 per cent; Los Angeles, 110; Marin, 50; San Bernardino, 50; San Jose, 85; Santa Cruz, 60; Stanislaus, 90; Sutter, 400; Tulare, 95; Ventura, 102; Yolo, 233; Yuba, 400.

(*g*) *Truck crops:*

Normal in Calaveras, Contra Costa, Fresno, San Luis Obispo, San Mateo, and Santa Clara. Alameda, 150 per cent; Imperial, 118; San Diego, 140.

2. Are there poor stands of grain to be plowed under?

Ans. No, in all counties except Calaveras, Kings, Modoc, Sacramento, San Joaquin, Solano, and Tulare.

3. Would silos increase livestock carrying capacity?

Ans. Yes, in all counties, except Orange and Santa Barbara.

4. Are materials available for building silos?

Ans. Yes, in all counties except Imperial and Inyo.

5. How many acres of young irrigated orchards?

Calaveras, 125 acres; Colusa, 3000; Contra Costa, 500; Del Norte, none; Eldorado, 2500; Fresno, 20,000; Glenn, 3500; Inyo, 1200; Kern, 4000;

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Kings, 7000; Lassen, 200; Los Angeles, 25,000; Madera, 3000; Mariposa, 20; Merced, 2000; Modoc, 35; Mono, none; Monterey, 2000; Nevada, 300; Placer, 3000; Riverside, 18,000; Sacramento, 5000; San Benito, 4600; San Bernardino, 23,000; San Diego, 2500; San Joaquin, 2000; San Luis Obispo, 100; Santa Clara, 4000; Santa Cruz, 1000; Shasta, 1000; Siskiyou, none; Solano, 300; Stanislaus, 2000; Sutter, 42; Tehama, 1000; Tulare, 500; Ventura, 5850; Tuolumne, 330; Yolo, 500; Yuba, 2000.

6. How many acres of young unirrigated orchards?

Calaveras, 250 acres; Colusa, 5000; Contra Costa, 2000; Eldorado, 1000; Glenn, 200; Humboldt, 500; Lake, 1000; Marin, 200; Merced, none; Mono, none; Monterey, 1100; Napa, 2500; Nevada, 1000; Riverside, none; San Bernardino, 1200; San Diego, 500; San Joaquin, 1000; San Luis Obispo, 11,000; Santa Clara, 4000; Santa Cruz, 1000; Shasta, 300; Siskiyou, none; Solano, 1000; Stanislaus, none; Sutter, 700; Tehama, 500; Yolo, 500; Yuba, 3000.

7. Can irrigated areas be increased?

Ans. Yes, in all counties but Alameda, Fresno, Lake, Modoc, Mono, Plumas, Solano, Trinity, Tulare, Yolo.

8. Is there sufficient labor for present needs?

Ans. Yes, in Alameda, Calaveras, Contra Costa, Fresno, Kern, Los Angeles, Madera, Mariposa, Mendocino, Merced, Nevada, Orange, Placer, San Benito, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Siskiyou, Stanislaus, Tehama, Trinity, Tulare. Answer no, in all other counties.

9. Number of men required for increased crops?

Butte, 5000; Calaveras, 300; Colusa, 5000; Contra Costa, 6000; Del Norte, 75; Eldorado, 500; Fresno, 500; Glenn, 1500; Humboldt, 225; Imperial, 7500; Inyo, 150; Kern, 3000; Kings, 2500; Lake, 300; Lassen, 14; Los Angeles, 750; Marin, 200; Mendocino, 2500; Merced, 500; Modoc, 500; Mono, 50; Napa, 1000; Nevada, 100; Orange, 700; Placer, 500; Plumas, 700; Sacramento, 10,000; San Bernardino, 1000; San Diego, 1000; San Joaquin, 3000; San Mateo, 2000; Santa Cruz, 300; Siskiyou, 500; Sutter, 1000; Tulare, 5000; Ventura, 4300; Yuba, 750.

11. Is there sufficient local money for financing farmers?

Ans. No, in all counties except Calaveras, Contra Costa, Fresno, Glenn, Merced, Nevada, Sacramento, Stanislaus, and Sutter.

12. Do owners of additional land have capital to crop it?

Ans. Yes, in all counties except Calaveras, Eldorado, Glenn, Imperial, Inyo, Kings, Lassen, Madera, Mariposa, Modoc, Nevada, Sacramento, Santa Cruz, Shasta, Siskiyou, and Stanislaus.

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13. Is straw burned.

Ans. Yes, in Alameda, Butte, Colusa, Contra Costa, Eldorado, Glenn, Imperial, Kings, Madera, Modoc, Monterey, Sacramento, San Joaquin, San Luis Obispo, Santa Barbara, Shasta, Siskiyou, Stanislaus, Tehama, Tulare, Yuba. Answer no, in all other counties.

14. Is manure conserved?

Ans. Yes, in practically all counties.

15. How do carrying capacities of pastures compare with normal?

Contra Costa, 25 per cent; Kings, 30; Kern, Merced, Nevada, San Joaquin, and Stanislaus, 40; Colusa, Fresno, Lake, Monterey, Napa, Orange, Placer, San Mateo, Santa Clara, Santa Cruz, Shasta, Siskiyou, Sonoma, Tulare, Yolo, Yuba, 50; Butte, Eldorado, Marin, Mariposa, Sacramento, San Joaquin, Sutter, Tuolumne, 60; Amador, Calaveras, Imperial, Mariposa, San Benito, Solano, Trinity, 70; Inyo, Santa Barbara, Ventura, 80; Los Angeles, San Bernardino, 90; Del Norte, Humboldt, Modoc, Plumas, normal.

16. Number of acres of new land which can be profitably plowed for summer fallow?

Alameda, 7500; Amador, 10,000; Butte, 20,000; Calaveras, 250; Fresno, 500,000; Glenn, 20,000; Humboldt, 20; Kings, 50,000; Lassen, 8500; Los Angeles, 4000; Mariposa, 11,000; Modoc, 5000; Monterey, 40,000; Placer, 40,000; Riverside, 30,000; San Bernardino, 5000; Siskiyou, 25,000; Yuba, 5000. All the other counties answered "none."

17. Condition of livestock?

Normal in Alameda, Calaveras, Colusa, Eldorado, Los Angeles, Marin, Madera, Mariposa, Merced, Mono, Orange, Sacramento, San Benito, San Francisco, San Mateo, Santa Barbara, Santa Cruz, Tehama, Tuolumne, Ventura. All the other counties reported condition of livestock to be below normal.

18. Can number of poultry and rabbits be increased?

Ans. Yes, in all counties but Alpine and Trinity, provided increased feed is produced.

19. Can better use of garbage be made by feeding to hogs?

Ans. Yes, in Alameda, Amador, Calaveras, Contra Costa, Glenn, Los Angeles, Placer, San Diego, San Joaquin, San Luis Obispo, San Mateo, Santa Clara, Santa Cruz, Stanislaus, Tehama, and Yolo. All the other counties answered "No."

20. To what extent are local demands for vegetables supplied?

Entirely in Alameda, Los Angeles, Madera, Orange, San Benito, San Joaquin, San Luis Obispo, San Mateo, Santa Clara, Siskiyou and Trinity. In other counties the following percentages of total need only are pro-

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duced: Calaveras, 45; Colusa, 75; Del Norte, 40; Glenn, 10; Imperial, 80; Kern, 60; Kings, 50; Lassen, 35; Marin, 50; Mariposa, 75; Mono, 50; Monterey, 50; Nevada, 20; Placer, 5; Plumas, 60; San Bernardino, 25; San Diego, 85; Santa Barbara, 50; Santa Cruz, 75; Shasta, 10; Solano, 50; Sonoma, 85; Stanislaus, 50; Sutter, 10; Tehama, 75; Tulare, 50; Ventura, 60; Tuolumne, 50; Yolo, 10; Yuba, 10.

21. Can supply of vegetables be increased?

All counties answered "Yes."

22. Do school vacations come at proper period?

Ans. Yes, in Alameda, Amador, Calaveras, Del Norte, Glenn, Humboldt, Inyo, Kern, Lake, Lassen, Mariposa, Mendocino, Modoc, Mono, Plumas, San Diego, San Mateo, Santa Clara, Santa Cruz, Shasta, Siskiyou, Sonoma, Sutter, Tehama, Trinity, Tuolumne, Yolo, and Yuba. The other counties answered "No."

At 2 P.M. of each day a public mass-meeting was held and speakers presented to the communities the fundamental considerations of the food supply problem in California. Specific recommendations were given for increasing the forage and other crops in each county.

Reports from all the counties visited indicate that the sentiment aroused at these meetings resulted in an increased cropping of land to sorghums and beans. The important rôle the farmer is to play in this war was presented in a way that caused every farmer attending the meetings to feel a sense of personal responsibility to his government. The benefits of such a feeling cannot be measured.

The following table shows the field parties visiting each county and the person or persons who organized the meeting within the county:

County	Hearings conducted by	Meetings arranged by
Alameda	W. T. Clarke B. A. Madson J. W. Nelson Geo. Robertson	M. A. W. Lee, County Farm Advisor
Amador	W. L. Howard W. T. Pope L. S. Smith	E. T. Katok, Forest Supervisor
Butte	H. E. Van Norman C. B. Lipman G. W. Hendry	Earl Mills, Horticultural Commissioner
Calaveras	W. L. Howard W. T. Pope L. S. Smith	R. W. Ayers, Forest Supervisor
Colusa	H. E. Van Norman C. B. Lipman G. W. Hendry	L. R. Boedefeld, Horticultural Commissioner

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County	Hearings conducted by	Meetings arranged by
Contra Costa	W. T. Clarke Geo. Robertson B. A. Madson J. W. Nelson	F. T. Swett, Horticultural Commissioner
Del Norte	T. Francis Hunt C. W. Rubel	E. D. Doxsee, District Club Leader
El Dorado	H. E. Van Norman C. B. Lipman G. W. Hendry	J. E. Hassler, Horticultural Commissioner
Fresno	B. H. Crocheron C. F. Shaw E. C. Voorhies S. P. Frissell	F. P. Roullard, Horticultural Commissioner
Glenn	H. E. Van Norman C. B. Lipman G. W. Hendry	W. H. Heileman, County Farm Adviser
Humboldt	T. Francis Hunt C. W. Rubel H. S. Maddox	A. H. Christiansen, County Farm Adviser
Imperial	H. J. Webber	Paul Dougherty, County Farm Adviser
Inyo	V. C. Bryant	E. M. Nordyke, Horticultural Commissioner
Kings	B. H. Crocheron C. F. Shaw E. C. Voorhies S. P. Frissell	Fred K. Howard, Horticultural Commissioner
Kern	B. H. Crocheron C. F. Shaw E. C. Voorhies S. P. Frissell	G. C. Kreutzer, County Farm Adviser
Lake	T. Francis Hunt C. W. Rubel	F. G. Stokes, Horticultural Commissioner
Lassen	G. H. True R. F. Miller	A. H. Taylor, Horticultural Commissioner
Los Angeles	H. J. Webber R. S. Vaile L. D. Batchelor A. D. Shamel W. B. Rowland	William Wood, Horticultural Commissioner
Marin	T. Francis Hunt C. W. Rubel G. H. Hecke	T. P. Redmayne, Horticultural Commissioner
Mariposa	W. L. Howard W. T. Pope L. S. Smith	L. A. Benedict, Forest Supervisor

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County	Hearings conducted by	Meetings arranged by
Modoc	G. H. True R. F. Miller	W. G. Durbin, Forest Supervisor
Monterey	W. T. Clarke B. A. Madson J. W. Nelson Geo. Robertson	E. K. Abbott, Horticultural Commissioner
Madera	B. H. Crocheron C. F. Shaw E. C. Voorhies S. P. Frissell	T. C. Mayhew, County Farm Adviser
Mendocino	T. Francis Hunt C. W. Rubel	C. Van Dyke, Horticultural Commissioner
Merced	B. H. Crocheron C. F. Snaw E. C. Voorhies S. P. Frissell	A. E. Beers, Horticultural Commissioner
Napa	T. Francis Hunt C. W. Rubel G. H. Hecke	H. J. Baade, County Farm Adviser
Nevada	H. E. Van Norman C. B. Lipman G. W. Hendry H. Weinstock	D. F. Norton, Horticultural Commissioner
Orange	H. J. Webber R. S. Vaile L. D. Batchelor A. D. Shamel W. B. Rowland	Roy Bishop, Horticultural Commissioner
Placer	H. E. Van Norman C. B. Lipman G. W. Hendry H. Weinstock	E. O. Amundsen, County Farm Adviser
Plumas	G. H. True R. F. Miller	D. N. Rogers, Forest Supervisor
Riverside	H. J. Webber R. S. Vaile L. D. Batchelor A. D. Shamel W. B. Rowland	H. J. Webber
Sacramento	H. E. Van Norman C. B. Lipman G. W. Hendry H. Weinstock	Carl Williams, County Farm Adviser
San Benito	W. T. Clarke B. A. Madson J. W. Nelson Geo. Robertson	L. H. Day, Horticultural Commissioner

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County	Hearings conducted by	Meetings arranged by
San Bernardino	H. J. Webber R. S. Vaile L. D. Batchelor A. D. Shamel W. B. Rowland	J. P. Coy, Horticultural Commissioner
San Diego	H. J. Webber	H. A. Weinland, County Farm Adviser
San Francisco	W. T. Clarke B. A. Madson J. W. Nelson	Dudley Moulton, Horticultural Commissioner
San Joaquin	B. H. Crocheron C. F. Shaw E. C. Voorhies S. P. Frissell	R. D. Robertson, County Farm Adviser
San Luis Obispo	W. T. Clarke B. A. Madson J. W. Nelson Geo. Robertson	S. F. Christierson, Horticultural Commissioner
San Mateo	W. T. Clarke B. A. Madson J. W. Nelson Geo. Robertson	Newton Peck, Horticultural Commissioner
Santa Clara	W. T. Clarke B. A. Madson J. W. Nelson Geo. Robertson	Earl L. Morris, Horticultural Commissioner
Santa Barbara	H. J. Webber	C. W. Beers, Horticultural Commissioner
Santa Cruz	W. T. Clarke B. A. Madson J. W. Nelson Geo. Robertson	W. H. Volck, Horticultural Commissioner
Shasta	G. H. True R. F. Miller	G. A. Lamiman, Horticultural Commissioner
Siskiyou	G. H. True R. F. Miller	W. L. Kleaver, Horticultural Commissioner
Stanislaus	B. H. Crocheron C. F. Shaw E. C. Voorhies S. P. Frissell	C. M. Conner, County Farm Adviser
Solano	H. E. Van Norman C. B. Lipman G. W. Hendry H. Weinstock	J. W. Mills, County Farm Adviser
Sonoma	T. Francis Hunt C. W. Rubel G. H. Hecke	O. E. Bremner, Horticultural Commissioner

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County	Hearings conducted by	Meetings arranged by
Sutter	H. E. Van Norman C. B. Lipman G. W. Hendry H. Weinstock	H. P. Stabler, Horticultural Commissioner
Tehama	H. E. Van Norman C. B. Lipman G. W. Hendry	C. B. Weeks, Horticultural Commissioner
Trinity	G. H. True R. F. Miller	W. C. Heustis, Forest Supervisor
Tulare	B. H. Crocheron C. F. Shaw E. C. Voorhies S. P. Frissell	C. F. Collins, Horticultural Commissioner
Tuolumne	W. L. Howard W. T. Pope L. S. Smith	R. W. Ayers, Forest Supervisor
Ventura	H. J. Webber R. S. Vaile L. D. Batchelor A. D. Shamel W. B. Rowland	A. A. Brock, Horticultural Commissioner
Yolo	H. E. Van Norman C. B. Lipman G. W. Hendry H. Weinstock	N. P. Searls, County Farm Adviser
Yuba	H. E. Van Norman C. B. Lipman G. W. Hendry H. Weinstock	C. W. Harney, Horticultural Commissioner

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OBSERVATIONS ON THE RECENT AGRICULTURAL INQUIRY IN CALIFORNIA*

MADE BY DIRECTION OF THE COMMITTEE ON RESOURCES AND FOOD SUPPLY OF THE STATE COUNCIL OF DEFENSE

By Thomas Forsyth Hunt

There are presented herewith copies of the report of each of the eight parties which conducted and completed an agricultural inquiry in California in the twelve days ending April 27, 1917. A study of the data and recommendations of these committees is essential to a complete presentation of the inquiry. It is intended with your permission to print these summaries together with other special reports and documents in the Annual Report of the College of Agriculture where due acknowledgement will be made of all the agencies and individuals who have so generously assisted in conducting this inquiry and without which its success would have been impossible. For the sake of brevity, I propose to restrict myself to the presentation of certain conclusions that have been impressed upon me not alone by the study of the large mass of data collected, but also by other facts which have come to my attention since making a previous report to this committee.

I shall not be disappointed if you do not adopt the conclusions. I am conscious of the steps through which every nation has gone which prosecutes to a final conclusion a war of the first magnitude. It first exhorts, it next admonishes, it then threatens, and finally it compels. This nation can hardly hope to escape these steps if war continues for three or more years. The best that can be hoped is that the steps may be shortened. It is, however, desirable that you who have placed upon you such grave responsibilities should be able to see to the end of the road.

Acting under your instructions an agricultural inquiry was conducted to determine as far as such an inquiry could determine, the actual condition of crops, and to point out the desirability of raising

* Published May, 1917.

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summer forage crops to the end that the output of animal products be maintained. The parties making the inquiry also gave information about the growing of certain crops with which some farmers have not yet had any considerable experience.

As was to be expected, the farmers were everywhere found to be bending all their available capital and energy to the production of farm products. It is worthy of note that the men who conducted these inquiries came back inspired by the cordial support and the patriotic fervor with which the various audiences received them. Nothing in agricultural propaganda with which I have been more or less intimately connected for a third of a century has so impressed me as the enthusiasm with which these men returned from their two weeks' campaign.

It may be safely stated that never has so much capital or so much labor been expended in the production of farm crops in California as during the present season. Broadly speaking, yield of crops depends upon two factors: (1) capital, including labor, and (2) weather conditions. Unfortunately the rainfall has been deficient and temperatures have been rather uniformly below normal during several months. It is necessary to report, therefore, that notwithstanding the strenuous efforts of the farmers the total crop yields of the state will be below normal, although probably not the gross financial returns.

It is difficult to secure the actual facts through an inquiry of the kind conducted or to make a general statement that will apply to the state as a whole. The inquiry was, of course, mainly concerned in determining the yield of crops and in creating a surplus of food for our allies. The men giving testimony can hardly escape being influenced by their economic returns. A producer of prunes may anticipate only 90 per cent of a normal yield, yet if he has them contracted at 25 per cent above the usual price, he is apt to testify his crop is satisfactory, especially when with the anticipated high price for labor he reflects that it costs him less to harvest a 90 per cent crop. In the same county alfalfa under irrigation may be 20 per cent above normal, while barley hay on adjacent unirrigated land may be 50 per cent below normal. To what extent they offset each other is obviously dependent upon the relative acreage. Potatoes may be above normal in most of the counties not raising potatoes extensively but considerably below normal in regions where they are principally grown.

In general, however, field crops, that is crops other than fruits and vegetables are somewhat below normal in the Sacramento Valley, much below normal in the San Joaquin Valley and up to normal

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Sorghums are drought resistants.
Sorghums are an excellent substitute for corn.
Grow sorghum for grain and forage.
With irrigation, sorghums may follow grain hay.
Plant sorghums on any good, average soil.
Plant up to May 1.
On irrigated land plant up to June 25.
Prepare seed bed thoroughly with a two-inch mulch.
For grain, plant rows three and one-half feet apart; plants, four to six inches apart, in the rows; six to eight pounds per acre.
For forage, seed heavier than for grain; 30-40 lbs.
Plant seeds below mulch on moist soil.
For grain, plant dwarf milo, Egyptian corn or feterita.
For forage plant Kafirs or sweet sorghums.
Keep down weeds around young plants.
Cultivate to preserve mulch and conserve moisture.

Ask your Farm Adviser, or write the University of California, College of Agriculture, Berkeley

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chiefly in counties of relatively small acreage.* Irrigated crops are not so seriously affected in the San Joaquin Valley, but even here reports state that the cold spring has retarded the alfalfa so that one less cutting is generally anticipated. Speaking again in most general terms, the fruit situation from the standpoint of the producer and the fruit handler may aside from the question of labor be stated to be satisfactory. The indications are that fruit is not much below normal in yield, and owing to prevailing prices will bring to the state as much and perhaps more money than usual.

Some difficulty has been experienced by canners in securing tinplate and the wholesale stocks of glass jars were found to be low. A special inquiry was made by our parties which indicate that sufficient stocks of these containers are held by retailers to meet all probable demands. The College of Agriculture has recently published brief succinct instructions on the drying of suitable fruits, especially for those growers who are not accustomed to practice the well known methods of the larger operators.

The acreage of beans will probably be the largest in the history of the state. The acreage of sugar beets has also increased, although seasonal conditions causing some shortage of labor for thinning has in some instances resulted in a substitution of beans for beets. Although difficult to determine, because of properly assessing the relative influence of commercial and amateur planting, it is probable that the effective acreage of potatoes is not quite up to normal. The growing of vegetables on the farm for home consumption needs to be greatly extended in these critical times.

Owing doubtless to satisfactory prices which have prevailed for several years the ranges and native pastures are fully stocked with cattle and sheep. There is every evidence that these pastures will not be able this season to support adequately all the animals available. It is further fully established that reserves of grain, alfalfa and other forage are smaller than in any previous time in several years.

A vigorous campaign has been made to increase production of sorghums for grain and forage, and to increase silos for the preservation of forage sorghums. The proper officials of the Federal Government have been requested to make available for pasture the National parks of the state. The District Forester, Mr. Coert Du Bois, estimates that under forest service regulations approximately 30,000 head of cattle or their equivalent in sheep can thus be saved. It is estimated that there are in California 627,000 head of cattle or

* During the two months following this inquiry, there was, owing to favorable weather, an increase in grain crops amounting to perhaps 10 or 15 per cent.

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HOW TO WIN THE FIGHT FOR DEMOCRACY

1. Increase the Army and Navy
2. Build More Ships
3. Increase Food Supplies for our Allies

WHICH ARE YOU DOING

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equivalent in sheep which the native pastures can not successfully carry this season. Some will go to market at relatively low prices. If the rest can be held until November, some may be transferred to the valleys to be fed on alfalfa, grain hay, and sorghums including silage, while others may at present prices be shipped to the feed lots of the central west where Indian corn will doubtless be abundant by that time. The final outcome will be somewhat influenced by the time and character of the fall rains. Whether these cattle are fed in the valleys of California or in the feed lots of the central west, without doubt higher prices must be paid for animals on the hoof next year and in the years immediately thereafter than is now being paid.

If meat production is to be materially increased in California, the valleys must take a larger part in the industry than heretofore. This will come about by bringing steers from the ranges at an earlier age to be finished in the valley while breeding cows take their places on the range.

Progress can also be made by reducing the excessive loss of lambs by the use of lambing sheds, thus reducing the number of ewes necessary to carry on the ranges to secure a given crop of lambs. A member of the staff of the Division of Animal Husbandry has been detailed to go among the sheep raisers furnishing plans of a simple lambing shed and if possible bring about better care at this critical period of the shepherd's business. This effort is too late to be beneficial during the present season.

The valleys of California can greatly increase the production of pigs and chickens, but, in order to do so, food, particularly grain sorghums, must be raised. The farmer who undertakes to increase his supply of pigs without first or concurrently growing food for them is destined to disaster.

More of the poultry of California should be raised on the farm which produces the food that they consume. California has the most numerous, large, specialized poultry plants in the United States yet keeps less poultry and produces less eggs per capita than many, perhaps most other states. The reason is that poultry are not so universally raised as a by-product of the farm as elsewhere. Today poultrymen are sacrificing their flocks on account of the high price of feed.

If a farm raises one acre of grain sorghums there can be kept with profit 50 hens which would produce 500 to 600 dozen eggs each year. The seed for this acre costs about 50 cents and even without special machinery the planting can be done in less than half a day by the wife or daughter if necessary. There is perhaps no other part of the United States better adapted to raising poultry than California.

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FEED OR FIGHT

1. **RAISE MORE LIVE STOCK**

   It is impossible to overdo this business within the next five years, war or no war.

2. **WINTER FEED STEERS**

   Substitute cows on the ranges for steers over two years of age wherever practicable.

3. **SAVE LAMBS**

   Build lambing sheds to eliminate the excessive loss of new-born lambs. The U. C. College of Agriculture will furnish plans.

4. **INCREASE FARM FLOCKS**

   Keep small flocks of sheep on farms to conserve forage not otherwise utilized.

5. **DOUBLE PORK OUTPUT**

   Keep two brood sows instead of one wherever grain sorghums are available.

6. **SAVE DAIRY CALVES**

   Skim milk is a food. Dairy calves should not be sacrificed prematurely.

7. **GUARD AGAINST DISEASE**

   Report any outbreak of disease among domestic animals immediately to Dr Chas. Keane, State Veterinarian, Sacramento, Cal.

8. **SILOS CONSERVE FEED**

   Build silos for the storage of non-saccharine sorghums, sweet sorghums or Indian corn. The U. C. College of Agriculture will furnish plans and supervise without expense, the building of silos by community effort. The materials cost about $1.50 per ton capacity.

Ask your Farm Adviser, Forest Ranger, Horticultural Commissioner, or write to the **University of California, College of Agriculture, Berkeley, Cal.**

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The lack of poultry production except as a specialized and commercialized industry is due, doubtless, to the Californians' traditional dislike for small things.

Upon the important subject of fish, which your committee directed a report to be made, the investigations indicate that the supply can readily be increased to meet any reasonable demands. Doubling the supply of fresh fish is merely a matter of increasing the nets. I hesitate with my rather limited knowledge of the situation to offer concrete suggestions, but I am convinced that with further study it would be possible to increase consumption of fish without increasing the price to the consumer. By proper co-operation the consumers' prices may even be lowered. Here, as in many other cases, high prices paid are the fault of the habits and exactions of the consumer and can be remedied only by his assistance. At any time and particularly at this time, an abundant and wholesome supply of fish is an important asset to any community.

The most frequent statement found by examining the detailed reports on horses and mules is "supply about equal to present needs." Several counties report horses for sale, one county reporting some horses for sale because of the high price of feed. Independent investigations of horses available for the army are less optimistic. It is generally conceded that relatively few horses meet the cavalry requirements. It is also certain that there can be no considerable extension of the present cultivated area, nor more intensive cultivation of areas at present under cultivation without more power.

While in a military sense this country has been engaged in war but a brief period, if at all, yet from the standpoint of the labor and food supply the United States has been in this war since August, 1914. It is not strange, therefore, that the agricultural inquiry should develop the farm labor situation to be one of the high lights. Our entrance into the war as a military aid to the Allies will serve to intensify the situation somewhat, the extent to which this will occur being dependent upon the methods of taxation adopted to meet the war loans. It was reported to our inquirers that in one-half of the counties the labor supply was sufficient to meet present needs, while three-fourths of the counties reported they did not expect to be able to secure sufficient labor within the country to meet the peak load.

In considering the labor situation it is necessary to recognize that a belief in a shortage of labor is a chronic state of mind on the part of many producers. I began employing and superintending farm labor thirty-six years ago and I have been at it almost constantly ever since. During that time there has never been a year that farmers of

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a certain type have not complained about the shortage, or the high price of labor. All this has occurred in the face of the fact that most farmers are benefitted by the high price of labor, for most farmers labor with their own hands. In some cases most sensational statements have been made to our parties apparently with ulterior motives. These statements when investigated by men especially detailed for the purpose have been shown to be either grossly exaggerated or without any foundation in fact. However, after discounting this hereditary state of mind and the sensationalist who wishes to take advantage of his country's condition in the interest of his personal ends, there still remains an acute farm labor situation.

A member of one of our survey parties returned with this concise statement:

"The big fellow wants labor, the little fellow wants capital." This statement was based upon observation and not on any theoretical consideration whatsoever. Nevertheless, the fact is based upon the soundest economic laws and represents an age-long controversy. It is to the economic interest of the large property holder, who employs labor to do his work to have the rate of interest high and labor cheap. His economic interest is not served by rural credits. On the other hand, the renter, or the man with a small equity in his land who daily toils with his own hands has his economic status promoted by cheap money and dear labor.

Finding the situation as it is, the problem was attacked in three directions.

1. A farm to farm post-card canvass of the actual labor needs was begun, every farmer being asked to give the essential data concerning his individual needs. The following is a sample inquiry:

The ——— County Farm Bureau is compiling a labor directory. We would therefore like to know whether you will need help on your ranch this year—more than you can supply yourself. If so, please fill in the attached postal and mail. We will make a summary of the returns and assist you to secure help when you need it. Don't delay, but mail the postal at your earliest convenience.

(Return Card) .....Cal.,
.....1917.

I will need.....men and.....women and.....children during the period of.....days in the months of.....to help in..... (picking prunes, etc.)

I will provide:	I will pay:
Board and room.....	Per box .....
Camping grounds	Per ton .....
House	Per day .....
Water	Per month .....
Sanitary conveniences	

(Name).....

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Such a canvass is now being conducted in seventeen counties and will be rapidly extended throughout the state provided the results obtained in the seventeen counties justify such action.

2. Consideration has been given to the best methods of making a house to house canvass in all the large cities in order to develop the supply of labor which can actually be made available for farmers. Consultation with men of experience in handling the labor problem in the cities seems to indicate that this can be done more readily than was at first supposed possible. Your committee already has such voluntary offers as make it seem probable that this task, stupendous as it may at first seem to be, can be accomplished within two weeks whenever it is desirable to do it. Of course it could not be done except under the stress of the patriotic motive. It has not been deemed expedient to have this canvass made until more definite information concerning the character and extent of the farm labor and the time when needed have been obtained. Further, the work can be more effectively accomplished after the registration for enlistment has been completed.

3. A plan is being developed to make the largest possible use of the 47,000 high school boys of California. Before a state of war was declared, the College of Agriculture in co-operation with the U. S. Department of Agriculture and fifteen high school teachers had approximately 2000 high school and elementary boys growing crops in club contests.

The second week in April the college called upon these boys to grow additional crops and to volunteer their services in spreading agricultural propaganda and in otherwise assisting local agricultural officials. The response was so marked that on April 30 eight members of the staff of the College of Agriculture began a canvass in the high schools outside the large cities in an attempt to induce the 20,000 boys so situated to grow crops. The next step was to outline a plan by which the remaining available boys might be mobilized to help in the coming harvest. The plan was first informally outlined at a meeting of the members of the State and County Councils of Defense in San Francisco, Thursday, May 3, and unanimously endorsed.

It is not to be understood as a method of solving the whole farm labor problem, but only a certain important phase of it. It may also be pointed out that this is the only large question connected with increasing the food supply, and hence, with the prosecution of the war, that is not primarily a federal matter. The Federal Government has no jurisdiction over the state school system at present, and will have only an indirect one after July 1. In all other matters

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PROFIT OR LOSS

The University of California Department of Economics says: "There are two reasons for the vast increase in prices.

1st. The increase in money in circulation, including credit instruments.

2nd. Actual scarcity of food and an abnormal demand. War or no war, food prices generally will not fall in the next two years because:

1st. The money in circulation cannot be called in.

2nd. The abnormal war demand will absorb all possible increase in supply.

3rd. Hold-over stocks of primary foods have been consumed. This increases all other food prices.

The crops of wheat, barley and oats in the United States in 1915 were the largest in our history, yet prices were the highest since the Civil War."

DO NOT BE AFRAID OF OVER-PRODUCTION

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the state at best can act only in an advisory capacity. In the very nature of the case, as the war progresses, these state activities will become more and more inconsequential.

The important question is to secure appropriate action providing for the employment by the several boards of education of such teachers as may be needed. The State Board of Education may possibly be able to supplement this action by the use of Smith-Hughes funds amounting to about $20,000. If it has any question about the legal use of the funds it can easily have the national and state officers pass upon the question, i.e., P. H. Claxton, Commissioner of Education, Washington, D. C., and Wm. D. Stephens, Governor of California.

According to the Superintendent of Public Instruction there are 47,000 young men in the high schools of California. Not all of these will be available for employment on farms, because—(1) some will work at home; (2) others will work at other occupations; (3) some may not work at all. However desirable it may be to have these young men also supervised, it can hardly be said to be necessary for the purpose of meeting the present emergency.

When the employment of teachers is settled, then the method of placing and supervising the young men will need to be worked out by the State Council of Defense through its Committee on Resources and Food Supply. In some cases, particularly in the larger cities, the high school students will be taken to distant places to work in groups of ten or more. They will generally live in camps and have a common mess. When necessary, it will be the duty of the teacher to mobilize the required materials, to organize the camp, to make contracts with employers concerning pay, to determine that the boys are given only reasonable tasks to do, and to look after the welfare of the young men, especially during the unemployed hours. It is not to be the duty of the teacher to take the place of the employer in seeing that the work is properly done.

In other cases, particularly in the smaller towns, it will be necessary to scatter the students about one, two, or three in a place. In these cases it will be the duty of the teacher to make the arrangements concerning pay, to determine that the rooming and boarding accommodations are adequate, and to visit the farm periodically to determine whether the arrangement is satisfactory to both parties.

It is to be kept in mind that if the war continues for three years or more, many of these young men will become liable for draft. The important question, therefore, is not the amount of money earned or saved, but it is the physical condition in which these young men return to their homes and their school duties. Hence it is proposed that plans shall be developed to prevent overwork. For illustration, if a rancher needs eight men working ten hours a day, he would be furnished with ten men who would work only eight hours a day. If he paid $2.00 a day for ten hours work, each young man working eight hours a day would receive $1.60 per day. If $2.50 was the ten hour rate, then the eight hour rate would be $2.00. It is believed that these young men working eight hours a day would soon be able to render as effective service per hour as the usual farm laborer who works ten or eleven hours.

It is not the purpose of this plan to lower the price of farm labor, but rather to furnish additional labor at the time most needed, at reasonable prices and under proper living conditions, in order that the state may have a body of virile, well-trained young men. It is believed, therefore, that these young men should not be made available below a certain minimum wage, whether the pay is to

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be by the hour or by the piece. These young men should not be placed, either in groups or singly on farms, until the supervising teacher has determined that a reasonable wage can be earned by working eight hours, and this wage should not be less than four-fifths of the amount earned by farm labor working ten to eleven hours per day.

Everyone knows where the high schools of his community are, so that in so far as any county is concerned, the ability to supply the labor which high school men are able to perform, should not be difficult. There should be no difficulty in employers making their wants known. However, when it becomes necessary to move men from the large cities to adjacent or distant counties, a clearing house will be necessary. This task the State Council of Defense will undertake, through its Committee on Resources and Food Supply.

This plan was fully discussed at a conference between this committee and members and representatives of the State Board of Education on Monday, May 7, and was formally presented for action at the meeting of the Board of Education on Monday, May 14. On Wednesday, May 9, a group of twenty-four Berkeley High School boys went to one of the islands of the Delta to cut asparagus, in charge of a teacher of the Berkeley schools, who is paid his salary and expenses by the Board of Education. To make this initial experiment, Mr. W. B. Meek not only agreed to raise the price paid for cutting asparagus, but voluntarily organized suitable living conditions under the direction of the State Immigration and Housing Commission, which has been co-operating with your committee in the most vigorous fashion. It is reported that large numbers of boys have gone out from the high schools of the state, notably in southern California, to help cultivate or harvest crops.

Every man, woman and child on whatever pretext, who goes into the open country this summer, will help to relieve the food situation (1) by reducing the cost of transferring food from the country to the city; (2) by living on simpler fare, and (3) by consuming supplies which while perfectly wholesome and palatable, never find their way to the cities for purely economic reasons. If foreign labor is brought to this country, the mouths to be fed will be increased, but if the city population is transferred to the country a saving of food will result.

Although your committee has hardly touched the edge of this problem, it is evident it is going to be one that will require much patience and many readjustments. Even before war was declared $2.50 for an eight-hour day without board had become the customary wage for ordinary manual labor in all the larger cities of California. Farmers who employ considerable groups of laborers complain not

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without reason that their industry has not been organized on that basis, since they have had access to labor which did not find steady employment in the cities at that wage. Whether unfortunately or fortunately this class of laborers has since August, 1914, been gradually absorbed into the industrial activities of the nation and is no longer available for farm work at the old rate of wages.

The extra labor which the farmer will employ this summer and probably for several summers hereafter must be largely from those who have come to look upon $2.50 for an eight-hour day without board as a minimum wage. Just what is the equivalent of this wage in the open country it is difficult to state dogmatically, but it is safe to assert that the farmer will find it necessary to organize his business on a higher wage basis than at any time within the memory of most men now living. In trying to organize farm labor primarily to aid in winning this war, the writer has not been unmindful of the interests of the farmers themselves. He, however, finds the solution hopeless unless they will meet the situation at least half way both by offering increased wages, and what is equally important, better living conditions than have obtained in the past in some instances. This means without doubt that the farmer must get more for his crops than ever before. He will not continue and he cannot continue to employ labor at greatly increased prices without a somewhat corresponding increase in his products. The man who is raising crops with his own hands and the help of his family is in quite another category.

The plans just outlined are being carried out with every possible dispatch not because it is believed they will be sufficient to meet permanently the farm labor situation, but because they are the methods which it seems possible to put into practice at the moment. The farm labor problem can not be considered apart from the rest of the activities of the nation. Without doubt, if the war continues for three or more years, radical measures will be necessary. Many of the activities now conducted by able bodied men between the ages of eighteen and forty-five will either have to be eliminated or be conducted by boys under eighteen, or men over forty-five, or by women.

While certain indulgences necessarily must be curtailed, the experiences of the present war teach that it is not safe to limit unduly the opportunities for recreation nor to fail to recognize the value of modern labor conditions. Our allies have found that music and art have human values that may not be omitted in war times. Nevertheless there are some things that can be done with perfect safety. Men can run their own automobiles and women can for the most part do their own shopping. Both men and women can economize on dress.

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It is not necessary for any man between the ages of eighteen and forty-five to clerk in a retail store or wait on the table in any club, hotel, or restaurant. Furthermore, in any real war it is not done, as the English would say.

Every effort should be made to reduce the cost of retail delivery. Hence buying in large quantities, popularly referred to as hoarding food supplies, is to be commended. While the transition is taking place between the old process of microscopic telephone purchases and that of the personally selected wholesale purchases there will be, as in all other trade changes, certain derangements and hardships and if after the first spasm of fear or of righteousness as the case may be, is passed, the purchaser falls back into the old method then nothing but harm can come from it, but as a permanent system the so-called hoarding of food supplies which is nothing more than wholesale or original package purchases is to be fostered by every possible means, because it reduces the cost of retailing, which is approximately one-third of the consumer's dollar.

Everywhere our parties have gone the farmers have shown an undoubted patriotism. The following extract is submitted from a letter which was received from a farmer who attended one of our hearings.

"Speaking on the subject of patriotism, the present price of wheat is $3.85 per hundred, which is *too much*. I am willing to sell my crop for $2.50 per hundred, provided a large number of farmers will do the same. My crop will aggregate 4000 sacks, I believe, and I will give 10 per cent of it and roll it to market at my own expense and send it to the cities of the state to be given to the families who are or will be without food.

I will further state that if there is no patriotic movement of this sort I will sell my crop on the market and whatever it brings over $2.00 I will put it in a fund to buy other food products for the families who have no food."

Nevertheless, our parties could not help sense the undercurrent of fear concerning overproduction and the feeling in the minds of the listeners that our advocacy of a given crop or crops made overproduction just that much more certain. To offset this attitude a placard has been widely distributed entitled "How to win the fight for democracy," which aimed perhaps unnecessarily to indicate what alternatives were before the citizen who wished to do his "bit." A placard prepared by the University of California Department of Economics entitled "Profit or Loss" is being distributed in which it is asserted that "War or no war, prices will not generally fall within two years." This was done in an attempt to increase production in order that there may be a surplus of food for our allies. Along comes this unfortunate agitation for the control of food prices. It is barely

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conceivable that some person may work out a satisfactory plan, but the present discussion which means a thousand different things to seven million different farmers only causes the farmer to hesitate to extend his operations.

It is not true that the primary necessity is control of food prices. The primary necessity is a surplus of food for our allies. Such methods must be evolved and such sacrifices must be invoked as will produce this surplus. What shall it profit the United States if it reduces the price of wheat and thereby loses this war?

In order to make this situation clear I permit myself the following primer-like cross-examination:

The average farm-owning farmer is perhaps not going to be much affected by this discussion. He has his capital, his machinery, his animals, and the labor of his own hands. He is going to follow his usual course of doing the best he can with these agencies. If prices are not too low and labor not too high, he may perhaps extend his operations somewhat, but for the most part he is going his way through wind and weather feeding the nation in about the usual manner. He cannot be expected to do much more than he always does, because he generally does all he can, the assertion of unthinking people to the contrary notwithstanding. How then is increased production to be obtained in California? I presented at our hearing in San Francisco the situation as it appeared at that time, from which I quote in part as follows:

> What has a great city to do with the production of foodstuffs for our allies? The answer is that if anything more is done than is already being done, it must be by the people of the cities, primarily by those of the large cities. Most people think that the raising of a surplus of food products is a rural problem. It is not. It is an urban problem.
>
> Every farmer is now working at top speed. He is using every dollar of capital and every ounce of muscle he possesses. The farmers are anxious and willing to help, but without the aid of the cities they are powerless to do more.
>
> There are about one-quarter of a million persons in California engaged in agriculture and allied industries. There are approximately one million in other gainful occupations. In the United States as a whole of every three persons in gainful occupations one is engaged in agriculture; in California the ratio is one to five. This is no time to discuss reasons. Suffice it to say that assuming a three years' war, one-quarter of a million people now in the cities of California will be needed to win this war. Fifty thousand will be required for the army and navy and for ship building, and 200,000 will be required on the farms. Twenty thousand are needed at this moment in the open country.

Our inquiry shows that there are considerable areas of land now available for irrigation and water ready to be applied which is awaiting new capital and additional men to make them productive. In

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Why all the agitation concerning food?

IN ORDER TO FURNISH A SURPLUS FOR OUR ALLIES.

How can a surplus be obtained?

BY INCREASING THE PRODUCTION OF FARM PRODUCTS.

BY DECREASING CONSUMPTION AND ELIMINATING WASTE.

What is the most effective means of increasing production?

INCREASE IN THE PRICE OF FARM PRODUCTS.

What is the most effective means of decreasing consumption and eliminating waste?

INCREASE IN THE PRICE OF FOOD STUFFS.

What is the objection to agitation for the control of food prices?

IT CAUSES THE PRODUCER TO HESITATE.

IT MAKES THE CONSUMER INDIFFERENT.

When will the price of food stuffs ease off?

WHEN OUR ALLIES HAVE AN ABUNDANCE OF FOOD.

Is the sacrifice too great?

IT IS SMALL COMPARED WITH THE SACRIFICE THAT IS MADE BY THE SOLDIERS WHO HOLD THE FIRST LINE OF TRENCHES.

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co-operation with the State Engineer a conference was held on Tuesday, April 17, with a considerable number of water companies and later correspondence was conducted with others. On Friday, April 20, a conference was had with the State Railroad Commission and the State Water Commission with the result that the State Railroad Commission issued an order that during the period of the war water could be furnished at less than usual rates or free of charge without permanently dedicating the use of the water to the land. Through the efforts of the State Water Commission suitable legislation was enacted giving mutual water companies similar powers. It is estimated that approximately 200,000 acres of land will be brought under irrigation for the first time in 1917 which is above the normal increase and water for 500,000 additional acres will be available next year. In California it requires, normally, 25,000 men to cultivate half a million acres of land. For each person engaged in agriculture in the state in 1910 there were invested in land, tools and animals $7000. How can men in the cities be found who will use their capital or their labor as long as a threatened food control whose significance is unknown hangs over them? If this were the proper time to experiment with untried economic theories, however good they may be in themselves, it would not matter, but the necessity of the hour is a surplus of food for the allies. If the State Council of Defense can do anything to clear up this situation immediately it is not too strong to say that it will be doing a lasting service to mankind.

In response to the appeal for more power on farms made at the San Francisco hearing a Committee on Tractors was appointed by Mr. C. H. Bentley of your committee, with Mr. Adolf Mack of San Francisco as chairman. This committee has been actively engaged in considering the feasibility of mobilizing existing tractors and in discussing methods for increasing the manufacture of new ones. There is especial need of a plan to increase the number of effective hours per year per tractor. A system of tractor garages, where a number of machines would be kept, might be developed so that a farmer who may need a tractor not more than one, two or three days in a year may order his work done either by the day or acre. This would result not only in more land being plowed, but also in that the plowing would be more efficiently done. There are in California 100,000,000 acres of land of which approximately 5 per cent was under the plow in 1910.

If I do not misjudge the temper of the people they are ready to contribute rather freely to any humane or charitable enterprise which is the outgrowth of the present conflict. The response is particularly hearty when the aim is to relieve suffering. "Save your money for

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the Red Cross" is the common and often jocular expression which represents this wholly commendable attitude. On the other hand, there seems to be a settled conviction that anything that has to do with the prosecution of this war is a governmental enterprise and should be a direct tax on the people at large. I am not commenting upon the propriety of this point of view, but I call the attention of the committee to the reality with which it must deal if its efforts are to become effective.

One of the chief items which on April 10 your committee asked that consideration be given was the conservation of food and the elimination of waste. The machinery for this task was created by the appointment of a committee of dietitians and others with a member of your committee, Miss Ethel Moore, as chairman. A memorandum entitled "Seven ways in which money is wasted and how to save this waste" was immediately prepared and sent to 225 teachers of home economics in the state and widely circulated in the press. It was also placed in the hands of the president of the State Federation of Women's Clubs. A strenuous effort is being made to enlist this organization, with a membership of 40,000, as well as other women's organizations, in promoting the practice of economies. The subcommittee is preparing and distributing a list of menus, tracts on drying and otherwise preserving fruits and vegetables, and on the rearing of poultry. It is now fully established that the winter wheat crop of the United States will be below normal, probably so much below normal as to make it impossible for a bumper spring wheat crop to offset the winter wheat shortage. When the demands of our allies are taken into consideration there is every reason to believe that high prices for wheat must continue to prevail. The public should not be lulled into feeling that by some legerdemain they are going to secure cheap food in the near future.

There is every reason to believe that this country will have an abundant corn and oat crop. Fortunately, they are both admirably adapted to human consumption. Without doubt the supply of corn will be four times as great, and that of oats as great as the wheat required for home consumption. Notwithstanding the fact that the Indian corn crop of last year was the smallest in several years, there is in sight at this moment corn enough to furnish food for our population for a whole year if there were not a pound of wheat in existence. It is, of course, not desirable that wholesale substitution of corn and oats for wheat should be made, because the meat supply would thereby be curtailed. Nevertheless the consumer should be taught that the proper course is to cut down meat bills and to substitute for wheat,

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so far as practicable, corn, oats, rice, and barley. So far as the adult population is concerned this would probably result in a general increase in health. There is need of care, however, in making radical changes in the dietary of growing children, who are in special need of the kind of protein furnished by meat, milk, and eggs.

An investigation of the garbage of one city in California made by Dr. C. M. Haring of the College of Agriculture shows that if this garbage were fed to pigs, the pork produced would be equivalent to 1 per cent of the total food consumption of that city. Probably the most practical method for the householder to deal with this waste is to keep from three to six hens. Care should be taken not to keep too many fowls, because if the waste product becomes too small a proportion of the food consumed by them, they may no longer be economical. The College of Agriculture is publishing a circular on city poultry-raising, with plans for suitable quarters for a small number of fowls.

Belgian hare furnish a wholly nutritious and healthful source of meat. They, however, do not consume waste products, being best grown on a diet of dry alfalfa and barley meal.

It gives me pleasure to report that the probable allotment of funds from the Secretary of Agriculture for the further extension of the County Farm Bureau system will make it possible to serve you more efficiently in the future. Both the present facilities and these added ones are at your disposal subject to the approval of the President and the Regents of the University, which I am sure may be assumed.

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CONCLUSIONS

I have therefore in conclusion to report to your committee that the tasks that lie immediately before it seem to be as follows:

To bring the labor resources of the cities in touch with the labor needs of the country by a family to family convass of both city and country and to act as a clearing house for this information.

To organize tractor garages or similar methods of giving the farmers more power.

To urge city capital and city people to engage in the production of food in the open country, particularly on those lands on which water has recently been made available.

To further promote plans of meeting the livestock situation and to promote a larger use of the abundant supply of fish which can readily be increased.

To furnish organizations of women with information concerning the conservation of food and the elimination of waste and to impress upon them the great possibility of state and local associations in promoting economy in food and clothing and in eliminating such indulgences as are not strictly necessary to the best welfare.

To assure the producer that whatever food control may mean that prices of food products can not appreciably decrease in the next two years, and to warn the consumer that the sooner he adjusts himself to the present or higher scale of prices, the better it will be for him and for the cause for which this country is fighting.

And now finally, the pity of it all is that very little attention will be paid to most of these recommendations. There will be in the hands of the American public during the next two or three years more money and instruments of credit per capita than there ever were in any nation of the world, and there is every reason to believe that this country is to witness the most prosperous times and the most riotous living that it has ever known. In the meantime it is our allies who will suffer.

> For what shall it profit a man if he shall gain the whole world and lose his own soul?

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SUMMARY OF THE REPORTS OF FIELD PARTIES CONDUCTING AGRICULTURAL INQUIRY, APRIL 16–27, 1917

1. SOUTHERN CALIFORNIA

By L. D. Batchelor

Crop Conditions.—Citrus crops are normal or above in practically all counties. A total tonnage of 110 per cent of normal seems likely. Deciduous fruits are normal or above in all counties except Riverside and Orange, where the late frosts did some damage to the stone fruits. A walnut crop of 115 per cent of normal is anticipated. There has been an increased planting to beans in all counties except Santa Barbara, where this crop is already very important. A total tonnage of from 125 to 150 per cent of normal is indicated. A normal crop of beets is expected. Threshed grain is below normal on the dry-land areas, but equal to normal on the vast irrigated areas of Imperial County. The milo planting is above normal, mainly in Imperial County, where 100 per cent above the usual crop is expected. The potato area has been increased to a considerable extent in Santa Barbara, Riverside, and San Diego Counties. The total crop of the entire area will apparently approach 150 per cent of normal. Fresh vegetables for commercial purposes are apparently normal, but there is a marked increase in the number of home vegetable gardens. There has been considerable increase in the cotton acreage in both the Palo Verde and the Imperial Valleys; 150 per cent of the normal crop is anticipated.

Grain-hay will apparently fall from 30 to 40 per cent below the normal production. The carrying capacity of pastures is below normal in most instances, approaching 75 to 80 per cent of the usual amount. The alfalfa crop will apparently be below normal, as the acreage in Imperial County has been reduced to plant cotton and the cold, backward spring has reduced the tonnage throughout the entire area.

Intercropping.—This practice is normally well established in the coastal sections, where the bean crop has proved to be a reliable and profitable crop to grow between trees. The interior regions do not normally intercrop the orchard, due to lack of initiative, water shortage, or lack of adaptation of soil and climatic conditions to profitable crops. It will be possible to increase the intercropped areas of orchard land in Southern California by from 40,000 to 50,000 acres. This land naturally is already well cultivated and irrigated, and often includes the best agricultural property of the various sections. Much of the inland section will be planted to beans during the current year, as all indications point to a profitable disposal of that crop. Beans are by all means the most popular and apparently the most profitable intercrop for an orchard, winter cabbages or early potatoes coming second. There is a feeling that corn or grain sorghum may be harmful to the young trees as well as being less profitable than beans.

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There will be need of competent advice on bean culture in those sections where this crop is being grown for the first time this year.

Double Cropping.—This system can be profitably practiced in the warmer inland sections, where such a crop as milo may follow cantaloupes, barley, or any of the early vegetable crops. The coastal areas are less promising for a practical form of double cropping. Here the opinions are very strong that double cropping means two poor crops rather than one good one. The cool weather shortens the growing season in that area, while an abundant amount of irrigation water after a certain seasonable period serves only to cool the soil and retard growth rather than hasten it. The greatest area which will be double-cropped during this season and the one which gives greatest promise for this practice, is Imperial County, where there will apparently be a 100 per cent increase in acreage of milo planted, estimated at 100,000 acres, largely on land which has already produced one crop. Tepary beans might follow as a second crop after cantaloupes.

It has been suggested that early fall barley might well be planted in September and October between the rows of short-staple cotton and provide 50,000 acres of pasture for a short period. There is an anticipated shortage of forage for feeders in Imperial Valley next fall, due to much land being given over to cotton and milo.

Extension of Irrigated Areas.—The irrigated land could be greatly increased by the enlargement of irrigation systems already established; these areas, amounting to a total of 100,000 acres, more or less, which might be irrigated in 1918. Probably the most notable areas are: first, the San Joaquin ranch, at Tustin, Orange County, where there are 25,000 acres of land now being dry-farmed, which could be watered from wells already in existence, by merely extending distributing pipes; second, from 10,000 to 40,000 acres in Imperial County, water for which could be obtained in 1917 by a temporary weir in the Colorado River (after the current season the extra water will be obtained by a new and permanent "in-take" now under construction; however, if the farmers were assured of this late water which the weir would furnish, they could greatly increase their milo acreage this season); third, 15,000 acres in the San Fernando Valley, which could be brought under irrigation by the extension of distributing service. The practicability of developing these several projects may vary widely.

Surplus Water.—This will bring about an increased production during the current year by making use of extra water now held by private water companies and individuals. The recent action of the state legislature in passing an emergency water bill will make this greater production possible.

Labor.—There is a general shortage of labor throughout most of the district covered. At present this shortage is more acute in Imperial, Los Angeles, Riverside, and Ventura Counties, and unless some unusual steps are taken, will probably be more acute at harvest time. A general shortage in the back country of all counties seems more acute than in the country surrounding the larger towns and cities. The greatest shortage during the spring and early summer months will be felt in connection with the beet thinning in Ventura and Los Angeles Counties; the apricot harvest in Ventura County; cotton chopping, cantaloupe, grain, and alfalfa harvest, and milo planting in Imperial County. The shortage of labor for beet thinning is not due to a smaller number of laborers than usual, but rather to the fact that the growth of early beets

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has been retarded by cool weather, and therefore both early and late beets will need thinning at the same time. More men are in the beet fields than normally.

The most acute shortage will apparently come from September 15th to November 15th, and especially during October, when practically all the counties of southern California, excepting Imperial, will be harvesting one or more of the following crops: beets, beans, walnuts, apples, and grapes. There is an estimated shortage of from 7000 to 8000 laborers during the period of September 1st to November 15th for the crops mentioned. Furthermore, the cotton and milo harvest will begin in Imperial Valley and Palo Verde Valley before the above crops are fully harvested in the more northern sections. The Imperial Valley shortage is estimated at the present time as approximately 4500 men to work on the cotton and milo harvest from October 15th to January 30th. If it were possible to take care of the shortage on the coastal areas so as to hasten the harvesting of beets, beans, and walnuts as early as under normal conditions, or possibly even earlier, it might be practicable to move the necessary 4500 laborers to Imperial Valley for the cotton and milo. The large percentage of this labor must be done by men, especially on the beets and beans. However, women and children can be used very efficiently in harvesting walnuts, apples, and cotton. The suggestion was frequently made that the total county or local labor requirements could be reduced if the various agriculture interests would establish a clearing-house for labor. A plan might be thus arranged whereby each interest could handle a considerable number of men during their peak load, and an attempt be made to house properly and to employ such labor throughout the entire year. The evils of depending periodically upon migratory labor are especially emphasized in Imperial County.

The abnormal migration of Mexican laborers from one section to another during the current season has been due apparently to a high and fluctuating labor wage. The probable return of any amount of this labor to Mexico seems unlikely. Steps should be taken to gain the confidence of the Mexican laborer.

Recommendations have been made that industries which are employing men and energy in a manner not constructive to the welfare of the nation should be temporarily eliminated. Large amounts of labor and produce could be appropriated from the liquor business, thus raising the efficiency of thousands of men.

City improvement might well be delayed until after the war crisis.

The shortage of labor in Imperial County might be materially reduced if more favorable railroad rates were established to transport migratory labor in and out of the valley.

Machinery, Tools, and Work Stock.—There is apparently no abnormal condition in farm machinery and work stock in this region as a whole. No shortage is anticipated, with the possible exception of a lack of sufficient bean-harvesting machinery in San Bernardino County, where the acreage of beans has been increased about 700 per cent.

The point is further brought out, however, that the use of tractors in leveling and preparing land in some of the newer sections, as in the Palo Verde Valley, is a much more economical procedure than by the use of horses or mules. The tractors conserve both man power and capital, as well as time. None of the sections visited felt that there was any appreciable surplus of farm work stock.

Capital.—There seems to be a wide variety of conditions existing surrounding the availability of capital for farming operations. In Santa Barbara, Ventura, Orange, and Los Angeles Counties there is little or no complaint on the

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part of the farmer. On the other hand, the so-called back country, as Antelope Valley, Los Angeles County, and parts of San Diego County, as well as Imperial Valley in general, feel that money is not always available to finance farm operations; that is, on such terms as it is practicable for the farmer to meet. Crop mortgages are not sought after by the bankers of Imperial Valley this year, and in fact such mortgages will seldom be made until a crop is well started; in case of the cotton, for example, not until after it is chopped and there is indication of a normal harvest. Apparently the farm tenants and newcomers in most of the sections have difficulty in obtaining sufficient capital under the present banking conditions.

Seed.—There is no general shortage of the common farm and garden seeds for the current season. However, the supply of beans, onion sets, and sweet potatoes are short in certain sections. There will likely be an abnormally small carry-over for 1918. This especially is true of the crops which have been planted in unusual amounts this year.

The selection of high-grade seed may be the most economic means of increasing the production of our various annual crops. It seems important that steps be taken to provide the best possible grade of seed for the 1918 planting. The location of blocks of especially pure and desirable strains of the several crops might well be undertaken by the government agencies. If a pure strain of milo were planted, it would be possible to harvest it by machinery; whereas the present uneven growth due to mixed seed makes hand-picking necessary.

The proper storage of such seed and its sale to the farmers in 1918 at only a reasonable profit might well be assured.

Land for Summer Fallow.—Dry-farm land which might be summer-fallowed amounts to 11,000 acres, more or less; some of this land has not proved profitable during normal years of the past. The whole question of the increase in acreage of improved farm land during the period of the war may be debatable, as it is increased production rather than increased acreage that is being sought. With the shortage of farm labor and the time which is involved in bringing these areas under cultivation, the question might well be asked, cannot a greater tonnage be produced by a more intensive agriculture on land already cultivated?

Live Stock.—The condition of all cattle is apparently normal, with the exception of Los Angeles County, where their condition is considered to be slightly below average.

Dairy cattle are apparently normal (as to condition and number) throughout southern California, except in San Diego County, where the milch cows are increasing in number.

The number of beef cattle in the entire district is apparently normal with the exception of Imperial Valley, where the number of feeders is estimated to be only 75 per cent of normal.

Milch goats are becoming more prevalent in this area; animals are in good demand and the supply seems to be short.

A general decrease in the poultry population of the area seems very probable, due to the high cost of feed. In only two sections was there any apparent anticipation of increasing the poultry, namely, in Imperial Valley and Orange County. In the Imperial region, where there is a marked increase in milo planting, there is thought to be a 50 per cent increase of poultry. In Orange County it was felt that a possible increase of 10 per cent would be realized,

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notwithstanding the high price of feed. The small poultry raiser in some cases might profitably grow milo in the home garden following early vegetables, and thus make it more practicable to retain his flock.

Rabbits.—In general the increase in rabbit production was looked upon as a home enterprise. Only isolated cases considered this a commercial industry.

The hog population is believed to be below normal (Imperial Valley especially). No accurate counting is possible at present to verify this opinion. With the increase in milo planting, especially in this valley, it seems safe to encourage the production of swine even above the normal number. The marketing of hogs is not on a satisfactory basis in Imperial County; there is an apparent discrimination against even the corn-fed hog of this section. Alfalfa-fed and poorly fitted stock of the past may be responsible in part for this unfavorable differential. Steps should be taken to assist the hog raiser in the proper marketing of his product.

The probability of increasing the livestock in general seems doubtful. There is an apparent shortage of all kinds of grain hays and in general the production of alfalfa is below normal. This is due in part to the breaking up of large areas of forage land in Imperial County for the production of cotton, and a similar reduction of hay land in the coastal counties due to the increased bean acreage.

Vegetable Supply.—Local supplies of vegetables in southern California come to a considerable extent from without the counties. In Los Angeles and Orange Counties the local demands are largely met and quantities are exported. This condition is explained in part by the fact that soil and climatic conditions, and the proximity to the large quantities of stable manure to be had at a reasonable price, makes the section around Los Angeles especially well adapted to the production of vegetables. The opinion prevails in many of the outlying sections that the general vegetable markets of the community can be supplied more economically from without the county than from within.

Home vegetable gardens, however are much more common this year than usual, with possibilities of increasing the total production of vegetables. In San Bernardino County it is estimated that the production from home gardens will exceed the normal about 150 per cent. There is a need in many localities of public instruction in garden making, to be followed up throughout the summer months. The high-school instructors in agriculture might well be enlisted for this work.

The farming of vacant city lots is looked upon from many different angles. It depends in part on the adaptation of the soil for vegetable gardening. In such sections as parts of Los Angeles, Ventura, and Orange Counties, where natural conditions favor vegetable production, the farming of city lots may be followed with success, if the people are already equipped with the necessary tools and the water rates are low. However, the production of vegetables on city lots which are not adapted to agriculture and by people who are not farmers may be a questionable procedure.

Crop Pests prevailing in the sections visited include the various insects and diseases on fruit trees, which as a whole are well controlled. The grain and hay pests come in for only normal consideration, except in Imperial Valley, where the grasshoppers periodically do an excessive amount of damage. The bean aphis is prevalent in the coastal areas, but there is a great diversity of

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opinion as regards the damage done by this pest. Some farmers even maintain that the plant infested with aphis is as productive as a normal one.

There is a persistent demand for better squirrel and rabbit control in the back country of San Bernardino County, and in the Goleta section of Santa Barbara County. Apparently there will be an unusual number of aphids on the cantaloupes in the Imperial Valley, and on the walnut trees of the coastal counties; this damage is considerable every year. There is considerable complaint against the damage done by birds to the milo crops and the apricots in both San Bernardino and San Diego Counties, where these crops are grown in small isolated areas.

School Vacations usually coincide with the need for the child's assistance on the farm. In Imperial Valley, however, climatic conditions make it imperative that the vacation come in the summer rather than during the season of the peak-load of farm labor. In the walnut sections, the opinion prevails that in many cases a vacation should be given at the time of walnut harvest, as the children are very efficient in this work, and it is light and clean labor. For this purpose, vacations should occur in October. Some opinions indicate that the vacation normally coming at Christmas could better come in October in this emergency, as the vacation at Christmas time is practically useless so far as farm labor is concerned.

II. CENTRAL COUNTIES

(Including all of the San Joaquin Valley)

By B. H. Crocheron

Crop Indications.—The grain crops of wheat, barley, and oats will evidently be low during the present season. The acreage has increased some ten to twenty per cent in most counties, but the condition is poor, induced by the long, cold winter and by the lack of the normal amount of rain. The condition of the crop was poorer in the lower part of the San Joaquin Valley, outside of the sections where irrigation is practiced. In irrigated regions the grain crop appeared to be normal. Apparently in some counties more effort had been used to increase the acreage of wheat than that of barley. Evidently, all sections of the counties that could be easily sown to grain had been planted during the past winter in response to the high prices of grain in the market.

Fruit conditions were normal, or slightly above normal, in the five northern counties of the San Joaquin Valley, but in the lower part of the valley were far below normal. Indications were for a poor crop of deciduous fruit south of Fresno.

Summer crops, such as sorghums, beans, rice, corn, sweet potatoes, sugar beets, melons, etc., will undoubtedly be greatly increased. In many cases these increases range from 100 to 500 per cent, planted. This results from plantings in young orchards and vineyards and by sowing second crops on irrigated land. What the yields of these summer crops will be is yet too early to determine, since many of them are only now being sown, or in some cases the land is being prepared for later sowing. Shortage of seed is a serious consideration in many places where the farmers are unable to learn readily where supplies of seed can

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be obtained. In general, the high price of seed was not the ruling factor, but rather the lack of knowledge of definite places where the exact kind of seed could be had at a known price. Many local seed houses were entirely exhausted of their supply of feterita, milo, and other sorghums, as well as Tepary beans, Blackeye beans, etc.

Replanting.—Except in certain sections where irrigation was possible and where sub-irrigation prevailed, in the delta regions or close to rivers and sloughs, it was too late and the rainfall had been too deficient to plow up poor stands of grain for planting of sorghums during the present summer. No considerable acreage appeared where this practice could be advocated.

Intercropping.—There appear to be about 45,000 acres of young orchards and vineyards which will be intercropped during the present season with summer crops, such as grain sorghums or beans. Much of this land was apparently going into beans because of the high price of that product. In many cases it was in areas where beans had not previously been extensively grown. It appears doubtful whether beans will be always successful or whether the owners of the land fully understand the culture of that crop. It would doubtless be to the advantage of the food supply of the state to advocate the planting of grain sorghums more extensively where beans are now contemplated, except in cases where bean culture is thoroughly understood and where the farm practise is established.

Extension of Irrigated Areas.—In some of the more northern counties of the San Joaquin Valley, it is possible, in certain sections, to extend the area of irrigated lands. This will probably not result during the present season, since the land must be leveled, and in many cases the capital is lacking to undertake that work. For example, in the Turlock irrigation district it was estimated that there were 70,600 acres of irrigable land under the ditch for which water was available, provided the land was leveled. Settlers moving into that region had funds for the leveling of only a part of their land and had maintained a practise of leveling additional acres as funds were available. The 70,000 acres now unleveled and unirrigated represent the balance of the area. If means could be found to furnish capital to these settlers so that they, or agents for the irrigation district, could level that land, a considerable area would at once come under cultivation.

Farm Labor.—In general, labor appeared to be sufficient for immediate needs. Grave apprehension was felt, however, that later in the season there would be a great shortage of the usual itinerant labor. The practice and the plan has been to gather up in small towns bands of men to go about for harvesting work, picking of fruits, etc. If this itinerant labor should be lacking because of the army draft or because of higher wages in other occupations, there would be a very serious and immediate lack of farm labor in the San Joaquin Valley during the latter part of the summer. The number of itinerant men employed at the time of the "peak load" varied from 400 to 6000 men per county. Unfortunately, the "peak load" seems to occur about the same time over the entire San Joaquin Valley, namely, during the months of August, September, and October, the highest peak being about September 15th. Unfortunately, too, the schools have in the past gone into session sometime between the 1st to the 15th of September. Throughout the entire San Joaquin Valley, except in Kern County, it was felt that the postponement of the opening of schools to a month later would materially assist in meeting the labor situation,

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since much work done is of such character that it can be undertaken by children in the upper grammar grades and in the high-school classes.

Farm Animals, Supply and Condition.—In general, the supply of farm animals is at present almost normal, but the conditions of these animals is poor and evidently will become poorer still, due to the shortage of pasture and the high price of feed. Pasturage appeared to vary between 30 and 60 per cent of normal; probably not more than half the usual pasturage being available during the present season. It is expected that large numbers of cattle and hogs will be marketed owing to an immediate shortage of feed. In the lower San Joaquin Valley large numbers of hogs have been sold out during the late winter and spring owing to the shortage and high price of feed and the failure of the early alfalfa, resulting from the cold weather. This condition is equally true of poultry, since the poultrymen who purchase feed are unable to cope with the high price of grain, and are selling off their flocks very rapidly. Every possible effort should be made to warn ranchers that high prices for animals and animal products will obtain indefinitely and that they must maintain their breeding stock regardless of cost for feed. Undoubtedly the large crops of sorghums will later help out the situation. Because of the very late and cold spring, it was generally felt that one cutting of alfalfa had been lost; where five cuttings are usually made, growers believe they will obtain but four; where four cuttings are usual, probably only three will be secured. This will have an enormous effect upon the animal carrying-capacity of the San Joaquin Valley. Everywhere the opinion prevails that silos should be largely built by farmers who can afford them and that their use would greatly benefit the dairymen and stockmen. Undoubtedly, the silo has become popular in the San Joaquin Valley. Silo campaigns can well be promoted in all counties from Stockton to Bakersfield. In Stockton and Modesto the town garbage is used to fill in land. In both cities the authorities were requested to pass an ordinance requiring householders to separate the garbage from other waste products in order that it might be fed to hogs. Straw is finding a wider use for feed than it formerly had and in all sections where the farm area was small and the population dense, straw appears now to be used. In counties where large grain areas exist the straw is still being burned; this practice, however, appears to be dying away.

Making Farms Self-Sustaining.—In general, it appears that about 50 per cent of the local supply of vegetables is raised, the rest being imported from special vegetable growing regions. The restraining factor is often the scarcity of water, so that ranchers cannot successfully grow vegetables in competition with specialized vegetable growing regions, or more often it is generally accepted that a vegetable garden is not worth bothering with. Undoubtedly propaganda should be made to try to induce ranchers to maintain a family vegetable garden. In many cases flocks of chickens or one or two brood sows are not maintained on the ranches. This can be increased by public attention being called to their value in the present crisis when high prices for food products are prevailing. A general campaign of effort to make farm homes supply the needs of the farm family will in the present state of public opinion have a good effect upon the farm population and should be promoted in every way possible.

Better Use of Irrigation Water.—In many sections the irrigation companies have difficulty in delivering sufficient irrigation water after the middle of the summer. The irrigation companies claim that this is due to the lack of conservation on the part of the farmers, who use more water than is necessary,

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and that this in turn creates a water shortage. It is undoubtedly also true that water storage should be increased. It appears that the snowfall in the Sierras has been low during the past winter, and that although this water supply has been held in the mountains until the late spring, there will, nevertheless, be a serious shortage in some districts during the present season.

Due to the recent decision of the State Railroad Commission, companies supplying power for pumping are collecting bills closer than in the past, and many farmers find themselves unable to pay their power bills or their fuel bills for distillate and other oils used to run engines until the end of the season, when their crops give them money in hand. The companies, meanwhile, are insisting upon a thirty-day payment of purchases, and many idle pumping plants result. For example, in Tulare County the Mt. Whitney Power Company reports that they have an actual census of 216 gas engines of over 2000 total horsepower now not in operation, and that there are also 161 motors, totaling over 1500 horsepower, which are not connected with their power lines. The representatives of the company, however, were unwilling to state whether or not it was due to the more close collection of bills which is now practiced by that and other companies. An extension of credit for the purchase of power and for the purchase of fuel oil is needed in these areas.

Conclusions.—The general situation in the San Joaquin Valley is somewhat depressing, due to the weather conditions which have prevailed during the past winter and spring. These, however, being beyond control, can merit no more than passing mention.

The bad weather conditions may be offset by the fact that farmers are doing everything possible with their present knowledge and resources to increase the area and yield of crops. They realize generally that higher prices will prevail and that this is an opportunity to make unusual profits. There also is undoubtedly a widespread impulse to assist the nation in every way possible and to attest their patriotism by increasing the food supply of the state. Their limitations, however, are acute because of a lack of funds in hand or credit obtainable to extend farm operations. They are also restrained by fear of a labor shortage which will be so serious as to prevent the harvest of the crop.

General Recommendations

(1) *Finance.*—There are undoubtedly farmers who are unable to obtain sufficient credit, due to the fact that their farming was started on a "shoestring" as new settlers and they have not yet been able to obtain sufficient capital to extend their credit. While their local bank has sufficient funds, and is desirous of extending credit so far as possible, it is limited by the banking laws and the wisdom of not taking undue risks. It is highly desirable that a considerable sum of money be set aside by the state or some philanthropically inclined persons whereby farmers without banking credit who are approved by some state or federal agency on the basis of the quality of their land and the character and knowledge of the operator, could obtain loans upon unendorsed personal notes or upon their promise to pay at the time of harvest.

(2) *Labor.*—Some central organization should exist in each county whereby the labor needs of the farmers may be codified. These needs may be cleared through other agencies at local or distant points whereby available, itinerant, competent farm labor could be gathered together and presented for the needs of the farmers. It was quite apparent, for example, that in the San Joaquin

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Valley during the late summer months unusual labor demands will be made this year to harvest the greatly increased acreage of summer crops. These labor demands drop off sharply at the end of October or beginning of November, when thousands of laborers would be available for transportation to Imperial Valley, for example, for the harvesting of the cotton crop. A county farm bureau which employed a labor clerk could catalogue all demands for laborers from farmers and should be able to present the labor needs of the county in such form that it could be met by labor-collecting agencies in the large cities.

(3) *Information.*—A more intensive system of supplying farm information to ranchers is needed in all parts of the San Joaquin Valley. The present farm adviser system should be extended and intensified to embrace all types of information to farmers which could have a direct bearing upon the growing of crops. For example, farmers should be supplied with immediate information regarding the purchase of seed; the exact methods of planting new crops; the best varieties of grain sorghums to plant; the methods of harvesting beans; the erection of silos; the growing of silage crops; the use of garbage; the feeding of straw and other by-products. They should also be informed of the probable trend of markets, the current prices, the best methods of marketing their products, the type or condition of the product that the market wanted, and similar information. Undoubtedly in most counties of the San Joaquin Valley one farm adviser and four or five assistants could be kept busy throughout the entire season giving a real informational service to the growers.

III. SOUTH COAST COUNTIES

By W. T. Clarke

San Mateo County.—The great handicap in this county is to be found in unoccupied, undeveloped subdivisions of land that are of high agricultural value. There are from ten to fifteen thousand acres of land on the bay side of San Mateo County, and some five thousand acres on the ocean side of the same county, which could be used for intensive agricultural work, providing labor were available to handle the lands in question. It was brought out in the inquiry that for proper agricultural work in San Mateo County about one man to seven acres is necessary. The county is a big producer of certain truck crops, notably artichokes, cabbages and cauliflower. Unless the labor is furnished, the acreage heretofore mentioned cannot be developed. The school-vacation periods are so arranged as to make the young people's work of most use to the farmers.

Santa Clara County.—Investigation showed that it requires for the ordinary working in this county, about one man to twenty acres, throughout the year. For the peak load of labor in July, August, and September, greatly increased forces are necessary, meaning by this term "greatly increased," about one man, boy or woman to two acres; this in handling the fruit in the orchards, in the drying yards, and in the canneries. This labor supply is not handled locally, but must come in from abroad. The interesting fact brought out was that while San Jose, the largest town in the county, has arranged its school vacations to meet the labor demands, the country schools as a rule have not so arranged their vacation periods, and as a consequence the country school labor supply is not available at the time when most needed, that is, in the fruit season.

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This condition can be readily overcome if the school trustees choose to take action.

San Benito County.—The interesting fact shown in this county was that a considerable acreage could be placed under irrigation, providing it were possible for two electrical power companies to operate in the county. There are two power lines across the county at the present time. Only one of these power lines is, however, permitted, under the State Railroad Commission rulings, to operate there. Since the investigation, arrangements have been made by the Railroad commission to permit the use of power from the non-operating company in this county. If this is finally consummated it will mean the addition of many hundreds of acres to the irrigable area in that county for 1918. The same question of labor that arose in the previous counties noted is also found here. The county is a large producer of seed and also of sugar beets. Orientals are used in this work. Also, during July and August, from 500 to 800 white campers are used. The local supply is barely enough to meet the ordinary demand and does not meet the peak-load demand. For development in this county, under the intensive cultural methods there used, it requires one man to each ten acres to properly carry the crops.

Santa Cruz County.—Generally speaking, conditions of crops in the county are thoroughly good. The labor in the county is sufficient for present needs. It would require some three thousand men to develop fully the agriculture of this county. There are some ten thousand acres of land in Santa Cruz County that could be irrigated by the use of gravity ditches and by pumping. The labor situation here is bad, and any increased cropping presupposes a development in the labor forces.

Monterey County.—The same problem of needed labor supply was evident also here. The county requires about a thousand extra hands during the beet harvest, and these hands are usually supplied by floating labor, campers, etc., though there are a number of Japanese, Filipinos, and Hindus working in the county. Increase in agriculture in the county will depend upon the increase of the labor supply. In this county also there are two power companies serving the needs of the county, and serving them well. It developed in the inquiry in Monterey County, that the common bush rabbit and cottontail rabbit were doing an immense amount of damage, and resolutions were passed by the people assembled, requesting a modification of the protection of these creatures so that their numbers might be materially reduced and the losses caused by them reduced.

San Luis Obispo County.—In this county there are about 175,000 acres of land which are not now used under intensive agricultural work because of difficulties in transportation. This land lies in the neighborhood of Cholame and Shandon, and would not be usable until road systems are developed which would make it more readily accessible. The tract could be used in 1918 and afterwards if roads were provided. The county is fairly well supplied with labor, though there is not enough to carry the peak load. This has to be done by outside help, but is fairly well taken care of at the present time by campers and through city employment agencies.

Alameda County.—The high light points in this county were again the matter of labor to carry the "peak load," and also necessary additions to the regular labor force to increase agricultural production in the county. Generally speaking, the conditions are normal, though there is undoubtedly evidence of a

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falling off in stock production, owing to the earlier overstocking of certain of the ranches.

Contra Costa County.—In the words of one of the people in attendance, the labor situation seemed to be about this: "If we sell our products for better prices we do not begrudge paying labor more money, but we cannot see where the summer help in sufficient quantity is to be had at any price. Something must be done." The labor situation seems to be acute in this county. The Oriental is leasing orchards and is not available as formerly for farm work. There will undoubtedly be heavy losses in truck crops and in the fruit in this county on the rich delta lands if the labor problem is not solved.

San Francisco County.—The fact was brought out that there was a very considerable amount of labor available in San Francisco and in our other larger towns, providing this labor could be placed directly in touch with the demand in the country districts. A feeling of uncertainty, however, was expressed as being prevalent among those who sought work. They did not seem to be able to get into touch with the work in the country.

Summary.—In all of the counties visited the fact was brought out that ample capital was available and could be obtained by individuals desiring to use that capital for crop development. There is no tendency apparent, at least on the part of the banks, to hold back credit. The usual precautions as to security, of course, are demanded, but no unusual demands are being made and the person who is a good risk can have all the capital necessary on short notes for agricultural work.

The survey emphasizes the very pressing necessity of a fuller development and classification of the work offered in the country, and a fuller development of the forces seeking labor from our centers of population. Some form of getting the employer of labor and the worker in touch with one another is absolutely necessary, and because of the facts observed in the survey, the suggestion is offered that the labor forces, both adult and youth in our cities, be tabulated and classified so that it will be possible to get into touch with this labor readily, and that the labor demands in the country districts be also thoroughly canvassed through some central agency, so that the laborer and the employer may be brought together. This would necessitate studying the situation very carefully, both in the city and in the field, so that both the employee and the employer would be thoroughly protected. It would be possible to use the high-school teachers throughout the state as developing forces in getting at the supply of labor in the cities and towns, and where counties are supplied with county farm advisers it would be possible to get this labor supply in touch with the demand very readily. Where such organization as are under the control of the farm advisers do not exist, new organizations could be developed which would bring about this connection.

It is very evident that the farmer, both from patriotic motives and also from a knowledge of the fact that good prices may be expected for farm products, is doing his best, under the climatic and soil conditions prevalent, to bring about heavy production of crops. It is also evident that without more man power he cannot obtain the best results.

In the counties visited, the matter of the use of the tractor is as yet of minor importance. It is true that there are certain sections in the Salinas Valley where some of the work can be done by tractors. However, those sections are well supplied with tractors. The main work is intensive in its char-

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acter, requiring careful labor with the hoe and other such implements, and unless man power is developed in these counties, agricultural development cannot be greatly increased.

IV. INYO COUNTY

By V. C. Bryant

The general conditions of this county are somewhat below normal at the present time, owing to the late spring and the hard winter which has just passed. In general, the county cannot be considered as an intensive agricultural locality. There are a great many crops, such as potatoes and beets, that could be produced in this locality were it not for the fact that freight rates are too high to enable the producer to ship them out at a profit. One thing that would stimulate the agriculture of this locality very much would be to reduce freight rates upon agricultural commodities or secure some special rates as, for instance, a potato rate, fresh-fruit rate, etc.

Crop Indications.—The indications are that the acreage of potatoes, wheat, and sugar beets will be increased this year. Other crops are about normal or a little below normal, owing to the lateness of the spring.

Replanting and Intercropping.—There is practically no replanting to take place in this county that can be observed at the present time. The spring crops are not as yet planted and it remains to be seen whether or not replanting will be necessary with these. The young orchards in this county are for the most part intercropped, but the acreage of these is not large.

Extension of Irrigated Areas.—It is estimated that there is water enough in this valley to irrigate between 150,000 and 200,000 acres, whereas, at the present time, only about one-half of this amount is being irrigated. If some systematic distribution of the water, under some constituted authority, was put into force, a great deal of land which is now producing sagebrush could be converted into alfalfa fields and other fields of production.

Drainage.—There are about 50,000 acres of land in Owens Valley that are badly in need of drainage. A high percentage of this acreage is now being used for pasture purposes, whereas, if it were properly drained, it would make very fine farming land.

Farm Labor.—Owing to the activity of the mines in Inyo County, the supply of farm labor is very scarce, and a committee has been appointed to get into touch with the various farmers of Inyo County and secure from them accurate information as to the amount of labor needed and the time when needed. When this information has been assembled there is a possibility that this committee may call upon the State Council of Defense to put them into touch with a source of labor.

Machinery and Seed Supply.—There is plenty of farm machinery available to work all of the lands that are under irrigation and can be worked with profit in this county at the present time. The available supply of seed potatoes and seed beans is somewhat limited, and the particular variety (Red Kidney) of beans which does the best in this county can scarcely be secured. Aside from potatoes and beans, there seems to be a sufficient quantity of seed available.

Capital.—There is plenty of capital available at local rates of interest (7 to 10 per cent) to carry on the normal agricultural operations of the county.

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However, the drainage conditions might be improved and more land might be cleared and put under irrigation if there were a greater supply of capital at a reasonable rate of interest. As previously suggested, the acreage of this county could probably be doubled by making a more extensive irrigation system and by practicing a more judicious use of irrigation water, together with some drainage. To do this would require considerable capital.

Pasture Conditions.—The pasture conditions are below normal at the present time, owing to the lateness of the spring. A good share of the sheep and cattle are pastured on the national forests throughout the summer, and a good deal of this forest range is not in Inyo County, but is in Mono and other bordering counties.

Livestock is by far the greatest agricultural product of this county. There is some dairying throughout the county. According to estimates there are about 20,000 head each of cattle, sheep, and poultry, 3100 hogs, and 4500 horses. Last year 176,600 pounds of butter were exported from the county and about the same amount was consumed within the county. The stock is in poorer condition than it has been for many years, probably about 15 per cent below normal.

It is the opinion of the forest rangers of the Inyo National Forest that by expending a few thousand dollars towards installing additional watering troughs, making a few new trails and by seeding some denuded areas, the carrying capacity of these ranges could be very materially increased. This is especially true of the sheep ranges. It is recommended that these ranges be improved in this time of need.

Land for Summer Fallow.—There is no land available for summer fallow in this locality, owing to the fact that the rainfall is not sufficient to make dry farming profitable. All the tillable land must be irrigated.

Vegetable Supply.—About one-half of the vegetables used in Inyo County are shipped in. It would be possible to supply the greater amount of these locally should the people desire to do it. There is room for some campaign work along this line.

Crop Pests.—There are no crop pests in this county which do appreciable damage.

School Vacations.—School vacation comes at a time when the boys are of the greatest service to the farmers. The vacation period is from the first of June to the first of September.

V. EASTERN COUNTIES

By W. L. Howard

Conditions in all of these counties are very similar, in that the chief industries are mining and grazing. Farming, as a business, has been given little attention except in a few of the larger valleys in the lower foothills bordering on the San Joaquin Valley. The people as a whole, whether they live in town or country, buy nearly everything they eat. While this is not literally true, as home gardens and isolated fruit trees are widely distributed, they are not as numerous as they should be. Poultry are scarce, as well as hogs, sheep, and milch cows.

Before the output of farm crops can be greatly increased, water for irrigation purposes must be provided. Also the small farmer must be assured of

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a market for what he produces, as many can ill afford to buy seed at the prevailing prices unless they are practically certain of a ready sale at prices commensurate with the cost of seed.

Range feed everywhere was reported so short that cattlemen declared they would be fortunate if they were able to finish off 50 per cent of their cattle holdings. Without exception, the big cattle owners had little hope of being benefited by the prospective increase in summer forage crops that might be grown this year. It was their belief that they would not be able to pay the prices for feed that would be demanded by the valley farmers. However, it was agreed by all that the small ranchers might find ways of growing enough feed to enable them to provide their families with both meat and milk, neither of which is now produced in sufficient quantities to supply the rural communities and small towns.

These counties afford a fertile field for missionary work along the line of increased crop production from tilling the soil. The citizens of Calaveras County evinced an especially keen interest in learning how to grow summer forage crops, such as the grain sorghums and Sudan grass. Everywhere there was a great willingness to learn about the new crops and how to grow them. Local committees were appointed in each of the counties for the purpose of continuing the agitation for increased food production, and with a little assistance from the state and national government, undoubtedly much good will be accomplished.

Crop Indications.—While the foothill or mountain country is not a grain- or alfalfa-growing region, these crops are produced in all of the counties to a limited extent. Amador is perhaps the largest producer of grain and forage crops. There barley, wheat, and oats are grown chiefly for the grain, while in the other counties they are produced chiefly for the hay. On the whole, the grain acreage is normal to a little above, while the condition was reported to be from 10 to 20 per cent below normal on account of shortage in spring rainfall.

Replanting and Intercropping.—The acreage of grain in poor condition that could be plowed up and planted to summer crops was reported to be very limited. In a few instances this might be done if irrigation water were available.

There are practically no orchards that can be intercropped, as orchards are scarce except at high elevations and irrigation water is not available. A small acreage might be intercropped without irrigation.

Extension of Irrigated Areas.—Very little land in these counties is now under irrigation, but the people were nearly unanimous in their belief that the irrigated area could be extended, particularly in the Jackson, Ione, and Shenandoah valleys in Amador County, where 5000 acres or more could be watered by diverting water now used for power purposes. In Calaveras County there are extensive ditch systems which could be utilized at a comparatively slight expense by water secured from the Mokelumne River.

Farm Labor.—In the main there was to be found enough help to take care of such crops as are being grown, but if the crop acreage is to be increased, extra help in proportion will be needed. Nowhere was there found a surplus of farm labor. The time of peak load ranges from May to September, depending upon the kind of crops grown.

Machinery and Seed Supply.—Little shortage of farm machinery was found, although in a few instances more grain-harvesting outfits and threshers are needed.

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No one reported stocks of agricultural seed on hand. Because of the fact that seeds of all kinds appear to be purchased each year as needed, owing to the present high prices many small farmers are barely able to plant in a small way and wholly unable to increase their plantings.

Capital.—Money was reported plentiful by the big ranchers and scarce by the little ones. It was apparent that many earnest, hardworking settlers need financial help if they are to increase their crops.

Pasture Conditions.—The carrying capacity of pastures was found to be 25 per cent to 50 per cent below normal. This was attributed to the scarcity of rainfall during the spring. In some sections, particularly in Tuolumne County and in Mariposa County, the grass came up as usual, but on account of the dryness of the soil it began to turn brown when yet too short for grazing.

Resolutions were presented at meetings held in Tuolumne County, also in Mariposa County, asking that that part of Yosemite Park north of Yosemite Valley be opened up to grazing during the present season. It was estimated that this extra range would take care of about 10,000 cattle or their equivalent in sheep. This request has since been granted by the Department of the Interior.

Land for Summer Fallow.—Thousands of acres of grass land that could be summer fallowed were reported throughout the district. Since comparatively little farming has been done heretofore it is unlikely that much will be done this year in order to promote heavier crop production in 1918, unless local committees or other agencies continue to carry on a vigorous agitation. If farm advisers were available in each of these counties, or even if a man could travel from county to county and constantly advise with the farmers during the present season, there is no doubt but that crop production could be materially increased in the near future.

Live Stock.—The number of live stock on hand was reported as normal, but their condition is somewhat below normal on account of the shortage of range which left the stock in bad condition. It was believed that the number of cattle could not be materially increased because of the lack of feed. Stockmen were unanimous in saying that without more feed they could not hope to finish off more than half their present number of cattle. There appears to be no waste of straw, all of it being used to feed live stock.

There seems to be an opportunity for the agricultural organizations of the valley region to get busy and either purchase half-finished cattle and finish them off with feed that will be grown this summer, or make arrangements for selling their grain and roughage to the cattle owners of the mountain regions at reasonable prices. In this connection the cattle owners ought to be urged to fatten their cattle at an earlier age than they have been doing in the past. It was conceded that silos would increase the live stock carrying capacity of the counties, and building material for either wood or concrete silos seems to be abundant.

It was very apparent everywhere that poultry and rabbits could be very greatly increased, perhaps by a hundred per cent. Many objected to this suggestion because feed is too high-priced to permit of buying it for growing poultry. However, it was pointed out that there is scarcely a farmer that could not produce enough grain sorghum, sunflower seed, and alfalfa to feed perhaps several hundred head of both rabbits and poultry. While rabbits will thrive on alfalfa, both green and dry, the flesh is not firm enough to command a good price in the open market unless the animals are finished off on grain of some kind.

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Vegetable Supply.—Only 10 to 25 per cent of the vegetables now used in the mountain counties are grown locally. There is a vast field here for growing vegetables, not only in order to feed the population of the towns, but to take care of the large number of men employed in the mines.

The country in this section is not well adapted to growing large areas of vegetables in one place, but there are plenty of opportunities for growing such crops in special localities even though the plots might be comparatively small. In every community enough water could be found for irrigating small gardens.

Crop Pests.—No bad crop pests were reported except gophers and squirrels.

School Vacations.—In general, school vacations now occur at a time when the children are most useful on the farm.

VI. NORTH COAST COUNTIES

By T. Francis Hunt

Crop Conditions.—Since the north coast counties are not heavy producers of hay or cereals, the condition of these crops is of little importance. The acreage of these crops in Napa, Marin, and Sonoma counties is about normal, but the condition of the crops is poor. In the northern counties recent rainfall has made the outlook for these crops at least normal. The fruit outlook is reported above normal in every county. This is of particular importance in Napa, Sonoma, and Lake counties. Indications are for a heavy crop of prunes, apples, and pears. The trees have blossomed very heavily this spring. The good prices of these crops during the last few years have had the effect of making the growers more careful about the proper handling of the trees so that, as a rule, the trees are in better condition than normally and there should be a very heavy crop, barring unforeseen accidents.

Pasture conditions in the southern counties of this group are reported as only 50 to 60 per cent of normal. The winter weather conditions have been unusually bad. The winter was cold and the rainfall not only comparatively light, but it came in such a way that it did not help the pastures as under ordinary conditions and, as a result, the pastures are in an extremely bad condition. In the section north of Mendocino County where the pasture has been poor until recently, everyone seemed to be optimistic in regard to the pasture conditions for the remainder of the season.

The summer crops grown in this region are normally of little importance. Reports show a considerable increase in the acreage of corn, beans, and potatoes. While enthusiasm in regard to planting these crops is manifest and there is every indication that there will be considerable increase in the acreage planted, the total yield will not be such as to influence the food supply in the state as a whole.

Live Stock.—Beef cattle have come through the winter in poor condition and the general report was that herds would have to be reduced materially this fall on account of scarcity of feed. In some localities the cattle are unusually thin and would require very favorable weather and good feed to put them in condition.

Dairy cattle for the most part are in fair shape. Because of the high price of dairy products the dairymen have purchased mill feeds and alfalfa so that their herds have come through in very good condition. There is much discussion in regard to reduction of herds because of the extremely high prices of hay and concentrates and because of the difficulty of getting milkers.

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The stock of hogs is extremely low, in most places being 50 per cent of normal. In a few small localities, the stock of hogs has been practically sold off because of the high price that has prevailed during the last year or so. Although this condition is true in certain localities, the general indications are that the stock would be reduced considerably further because of the high price of feed.

The supply of horses and mules is sufficient for farming operations. There appears to be a scarcity of horses that might be available for cavalry purposes. It was difficult to get a fair understanding as to the number of this type of horses because there seemed to be a great deal of difference of opinion as to whether or not the horses available would come up to the government specifications.

Farm Labor.—Farm labor was invariably reported insufficient. In two counties, Napa and Sonoma, the shortage of labor will be acute during the fruit-picking season and much can probably be done in securing labor, largely family labor, for these counties from June to September. In the other counties the lack of labor is not so seriously felt, although many farmers are looking for additional men and help is hard to secure.

Farm Machinery.—No serious lack of farm machinery was apparent in any county. In a number of the counties it was thought that additional tractors could be used, but there seemed to be no definite plan or any definite piece of land upon which to put these tractors. It may be safely said that if present conditions continue for another year or more, about twice the number of tractors could be used in these counties to advantage. In these counties, if the bean acreage continues to increase, as appears probable, the need for small bean thrashers will be very great, but it would seem that there will be ample time to supply this need.

Finances.—In this section of the state there is plenty of capital available locally to finance farming operations. However, a feeling was noticeable to the effect that production could be increased if there were some capital available to aid farmers whose security was none too good. In other words, there are many honest, hard-working farmers who could put in additional crops if they could be supplied with capital, while their security is of such a nature that it would be difficult to get the ordinary banking laws to cover them. It was hinted on numerous occasions that the state or federal government could well finance many of these farmers who are having some difficulty in getting capital to increase production.

The supply houses have their normal stock of cans and fruit jars or have contracted for them to be delivered and do not fear any shortage in this regard.

Recommendations.—The committee felt safe in recommending in every county greater effort to produce feed for live stock and that throughout the entire section the use of the silo could be extended to great advantage. There is no doubt but that the building of silos throughout all the northern coast counties would materially add to the live-stock carrying capacity of the section.

There are great possibilities, particularly in Mendocino, Humboldt, and Lake counties in raising of both potatoes and beans. These counties are not particularly well adapted to the growing of summer crops which require considerable heat, but both beans and potatoes do very well and other growth could be increased markedly. In these counties there are possibilites of increasing the production this year. We also feel safe in recommending the use of better stock. This applies particularly to hogs.

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VII. NORTH CENTRAL COUNTIES

By H. E. Van Norman

Extension of Irrigation Areas.—Some steps should be taken to make available water in Placer and El Dorado counties. In both counties the general opinion was that the price charged for water is too great to permit of its use on the emergency crops. This matter should be taken up with the Western States Electric Company in El Dorado County and the P. G. & E. in Placer County.

In Placer County there is for this season a considerable amount of water going to waste below the power plant of the Pacific Gas and Electric Company, which could be diverted along the line of the stream and made available for the growing of crops east of Lincoln. Eventually, all this water will be used in ditches that are now under construction. The company said it could be diverted this season without any expense except that which would be incurred by the ranchers using the water, and local diversions can be made without prohibitive expense.

Colusa County reported a large area along the rivers which might be irrigated by pumping from the river and planted to a second crop.

Labor.—Rice growers anticipate a shortage of men and teams, also harvesters to properly handle their crop. They have tried to hire teams from outside districts. They complain of the inefficiency of the teams, and yet when we get the other side, we are told that the rice harvest is very hard on men and teams, and owners are unwilling to rent teams for rice harvesting because of the severity of the work.

In every county on the floor of the valley there was a demand for the universal closing of saloons to increase the efficiency of the present labor supply, by eliminating the loss due to the men laying off from one to several days after each pay-day, even though they come back to work after they are sober. It was also expressed that this would even bring a large proportion of the hobo class to work. There was a very insistent demand in several counties for some legislation or plan that would put to work the large number of men idling along the railroads who will not work when a job is offered to them, and yet they prey on the communities through which they move.

Butte County reported some land with water available by pumping, pumps and motors installed, which would not be cropped this season for want of someone to do the work.

Tehama County reported a 50 per cent decrease in the hop acreage, with a corresponding release of labor for other crops.

Capital.—There are a considerable number of small land holders in all of the newer settled section who have used all of their capital and credit for the purchase of their land and in most cases inadequate equipment of it, who could grow more crops if the purchase of seed could be financed. The amount of money involved in individual cases is not large.

Solano reported that men who were known locally can borrow needed funds for seed with resulting crop as security.

In Sacramento County it was pointed out that many of the small settlers are poorly equipped; they have a meager supply of farm machinery, they have bought poor horses, and generally speaking, are not supplied with facilities for proper handling of the land which they have.

Glenn County reported a shortage of binders for harvesting rice.

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Feed.—It is estimated there will be 100,000 tons of rice straw available, which, in the opinion of a number of ranchers who fed it last year, is valuable feed for carrying cattle through the winter. Some systematic organized effort should be made to have this saved and to have it available for the carrying of stock which otherwise may be short of feed.

One of Butte County's prominent farmers said, "If I had had one ton of rice straw per animal in the short months, my stock would have come through the winter 100 per cent better.

In the bean-growing area of these counties there is considerable bean straw which has heretofore been wasted, that might be made available for the feeding of sheep, and to a lesser extent for the feeding of cattle.

It was brought out in many counties that barley straw is still burned in large quantities.

Vegetable Supply.—Without exception the counties report that they are depending largely or wholly on outside shipments of vegetables to supply local demands. In a few cases they report that the mid-summer demands are supplied locally.

It is suggested that some serious consideration might be given to methods of and plans for encouraging the drying of vegetables; possibly the kilns used for drying hops might be adapted to the drying of vegetables, as well as the possibility of sun-drying.

In the district tributary to Sacramento there is a noticeable increase in the acreage of tomatoes and spinach being grown for the Libby, McNeil & Libby cannery.

School Vacations.—There seems to be a general concurrence of opinion that if the school vacation could be prolonged to the first or middle of October in the fruit section, it would materially help the handling of late fruits.

Intercropping.—Butte County was the only one that reported a general practice of intercropping in orchards.

Silos.—There was an appreciable interest in the building of silos in most counties and apparently a growing recognition of their value.

Poultry.—There was a noticeable lack of any general raising of poultry. There are a few people engaged in raising Belgian hares in each county that we visited.

VIII. NORTHEASTERN COUNTIES

By G. H. True

The general character of the six northeastern counties of the state, with the exception of the southeastern part of Shasta county, which extends into the Sacramento Valley, is very similar throughout. The region as a whole may be characterized as mountainous and of an altitude such as to give a climate comparable to that of the mountainous states north and east of California, and more or less like that of the middle west. Trinity County seems to stand by itself as a non-agricultural region, mining being the principal industry, a few cattle (estimates vary from 2000 to 5000 head) being the only export credited to the county outside of the product of its mines. Trinity County as truly as the British Isles is dependent upon outside sources for its food supply.

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Character of Agriculture.—Speaking generally for these counties it may be said that the range livestock industry is the principal one. The object of farming is to produce winter feed for the cattle on the range, and such supplies as are required by the mines of the region. While some wheat may be shipped out, it is safe to say that larger amounts of flour are bought on the outside. The counties do not produce either the pork products or vegetable supplies consumed.

Possible Extension of Agriculture.—The most important extensions to the farming areas in these counties are to be made as a result of the development of irrigation. Important developments along this line are under way in Siskiyou county, where 5000 acres will be put under cultivation in the vicinity of Montague during the present year. In Strawberry Valley it is stated that 3500 acres could be put under irrigation through the construction of proper irrigation systems, there being an abundance of water now unused. In Shasta County the Anderson Cottonwood Ditch now under construction is supposed to furnish water for 12,000 acres of new land, 3000 acres of which will be cropped this year. In Lassen County a project contemplating the use of water from Butler Creek will bring under cultivation some 7000 acres of land. Extension of cultivated area by dry-farming additions could be made in Lassen County by the plowing of new land in Honey Lake Valley, and possibly in the Madeline Plains, also by the development of low-lying lands in Big Valley in the vicinity of Bieber, where 8500 acres of land capable of yielding thirty bushels per acre could be plowed this year ready to crop next year if power were available. A few hundred acres could also be added to the cultivated area in Surprise Valley in Modoc County.

Live Stock.—The number of head of live stock throughout these counties is practically normal, the ranges being stocked throughout to their full capacity. On account of the past hard winter the surplus supply of feed for live stock on the ranches is completely wiped out, it having been necessary to ship hay into some of the remote regions at a cost of as high as $30 a ton to save animals from starvation. The season is at least a month late and while the indications are for good pasturage later, the outlook for the season as a whole is for less than a normal condition of pasturage. Spring crops had not been planted throughout most of the farming districts. On the whole, an increased acreage of grain was predicted but nothing could be said concerning the character of the crop.

The conditions for marketing live stock in Modoc County especially have not been satisfactory. During the last season there was but a single buyer in the field and but one price was offered. The cooperative system of marketing cattle whereby more satisfactory market conditions may be attained is needed.

Crop Pests.—The most injurious of crop pests seems to be the ground squirrel which is common throughout the whole region and injures grain crops to the estimated extent of 5 to 20 per cent. One man made the statement that his crop was injured to the extent of $1.50 per squirrel.

Power.—Throughout these counties there seems to be a sufficient supply of horse and mule power for the planting of this season's crops. In the region named, however, where there is a possibility of an extension of dry farming, this increased area would be brought under cultivation only through the use of power not now available. Detailed reference was made in our reports from the field to tractors in the vicinity of Susanville that might be available for certain months; also in Siskiyou County, of certain tractors now in use on the new irrigation project at Montague which might be available for certain parts of the year.

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It is thought that in Modoc County 250 head of horses weighing around 1300 pounds would be available for purchase after the grass had grown sufficiently to give them an opportunity to get into good condition. It is thought that 2500 head of horses and mules could be bought in Lassen County.

Labor.—In Shasta, Trinity, and Siskiyou counties there seemed to be no shortage of farm labor. Plumas, Lassen, and Modoc will need something like 2400 men during the season for haying and harvest in July, August, and September.

Capital.—Local banks throughout the six counties seemed to have sufficient money to finance all farm operations. Conditions under which money is loaned, however, are not such as to make it possible for the poor farmer whose land is of questionable value on account of climatic conditions, limited rainfall and unseasonable frost, to borrow money sufficient to take the necessary chances in the matter of cropping. It would seem advisable that some steps should be taken to bring before these people the possibilities of the use of the Farm Loan Bank. It is desirable, first, that they should have the advantage of a low rate of interest, and second, a just valuation of their land by such agency would result in a very much needed stabilizing of land values in regions where colonization is being attempted. Reference is made especially to the Madeline Plains in Modoc County and Butte Valley in northern Siskiyou County.

Summary.—In summarizing the situation in these counties it seems that urgent necessities lie along the following lines:

First, that every effort be made to increase crop production in order that meat-making animals from the range may be carried through the winter not only without loss, but without serious deterioration in flesh. Further, that steers to a larger extent than is now the case may be marketed from the range, making it possible to carry a larger number of breeding stock.

Second, that the range sheep men be urged to give most careful consideration to the possibility of improving the conditions of lambing practice to the end that serious losses now experienced be lessened.

Third, it seems advisable to urge families to make every effort to produce the home supply of vegetables, no matter whether living in villages or on farms. Also that farm cropping be so balanced that the counties in question grow their own supply of wheat for flour locally.

Fourth, co-operation in the distribution of products raised is very much needed, so as to avoid the same product being shipped out from one part of the county into another or into another county. Co-operation in the handling of labor should also be given serious consideration.

OUTSTANDING CONCLUSIONS FROM AN EMERGENCY IRRIGATION SURVEY OF CALIFORNIA BY THE COLLEGE OF AGRICULTURE OF THE UNIVERSITY OF CALIFORNIA CO-OPERATING WITH THE IRRIGATION INVESTIGATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE, AND THE CALIFORNIA STATE DEPARTMENT OF ENGINEERING

ELWOOD MEAD AND FRANK ADAMS, *Committee*

Summary:

(1) From 1899 to 1912 the irrigated acreage in California increased from 1,466,000 to 3,200,000 acres, or at an average rate of 135,000 acres per year.

Owing to unsatisfactory land settlement conditions, this rate of increase was not maintained from 1912 to 1915, yet the indications are that 1917 has not only

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brought a return to the normal, but that the widespread interest in increasing food production and, more particularly, the present high price of agricultural products have resulted in a very considerable additional seasonal increase for this year, possibly as much as 100,000 acres.

(2) Although, in the main, unavailable for use until qualified agricultural settlers have been placed upon the land, canals and principal laterals are already constructed sufficient to add an additional half million irrigated acres, and construction is now under way or arranged for, and due to be completed within three years, that will make irrigation water available to 300,000 acres more.

(3) Legal obstacles standing in the way of a more complete use of irrigation water controlled by public service and mutual water companies and individuals have been removed by action of the California State Railroad Commission and a special enactment by the legislature. Owing to the irrigation season being advanced when the war emergency arose, however, resulting opportunities for increased irrigation through the use of this surplus water have not been largely seized in 1917.

(4) Reorganization and consolidation of existing irrigation enterprises, completion of irrigation works now under way, efforts toward temporary or permanent adjustment of local irrigation controversies, and more complete and more careful utilization of regular irrigation supplies, have been definitely stimulated by the war emergency. A spirit of unwillingness to subordinate individual nterests involved in pending controversies over the use of water to the furtherance of the national good unfortunately, however, is not altogether lacking.

(5) If, in some instances, during the war emergency there can be a temporary exercise of superior national or state authority to stop waste of flood waters kept out of use through local differences but without permanent or substantial loss to those responsible for the waste, the effective additions to the irrigated area in California can be still further increased.

Recommendations:

There can be no question of the patriotic effort of many farmers and land owners throughout California to increase the irrigated area during the war emergency, nor of the great stimulus that has been given to increased production under irrigation by the present high level of prices of all agricultural products.

No enthusiasm for this response, however, should beeloud the fact that while highly commendable and advantageous, the irrigation increases during 1917 will be much less than would be possible if either state or national authority were so organized as to force utilization where there is now waste and furnish financial aid and direction where these are essential.

It is too early at this writing to ascertain the extent to which surplus water is being utilized in 1917 under the emergency order of the State Railroad Commission and the special act (chapter 191) of the 1917 legislature permitting emergency deliveries by mutual water companies and owners of individual irrigation plants. It is recommended, however, that the general extent of such use in 1917 be ascertained later in the 1917 irrigation season with a view to encouraging the extension of such use in 1918 if found practicable and beneficial during 1917.

It is further recommended that additional investigation be made by the proper agencies as to the extent to which the use of irrigation water can be extended in California in 1918 and subsequent seasons during the continuance of the war emergency, provided it is found desirable to establish and exercise such higher

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governmental authority as shall be found necessary to prevent waste and to force the temporary setting free, under conditions that will not jeopardize permanent rights, of all unutilized water that can be advantageously applied in irrigation during continuance of the need for maximum production.

Finally, it is recommended that the proper agencies continue the giving of advice and assistance to irrigators and irrigation communities in the practcal questions relating to the application of water to land and that every effort be made so far as lies within our means to insure that no irrigated land in California remains out of use during the period of the war through lack of information as to its location or as to feasible means of applying the irrigation water needed to make it productive.

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A COMPARISON OF ANNUAL CROPPING, BIENNIAL CROPPING, AND GREEN MANURES ON THE YIELD OF WHEAT

BY
B. A. MADSON

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A COMPARISON OF ANNUAL CROPPING, BIENNIAL CROPPING, AND GREEN MANURES ON THE YIELD OF WHEAT*

By B. A. MADSON

It has been observed that the productive power of the arid and semi-arid soil of the west is more often limited because of an insufficient supply of moisture or because of improper physical and biological conditions than because of a lack of certain fertilizing elements. This is especially true where dry farming is practiced, in which case the cereals constitute the principal crop grown. In the more humid sections, where water is usually abundant, corresponding defects in physical and biological conditions may generally be corrected by the use of systems of crop rotation. Under arid conditions the development of a comprehensive system of crop rotation is rendered somewhat difficult because of the limited number of crops adapted to these conditions. Some modification of this character, however, is necessary in the system of grain farming in California, as evidenced by the fact that wheat production in the state has decreased more than 80 per cent during the past ten years, a condition which can be attributed largely to the deleterious effects of continuous one-sided cropping.

To overcome this deficiency of crops, a year of fallow and addition of organic matter to the soil by the use of cover crops have been advocated. The year of fallow is recommended primarily as a moisture-conserving measure, to make possible an adequate supply of moisture in the soil for a maximum crop at all times. The use of the cover crop, on the other hand, is recommended as a means of maintaining the supply of humus which is lost so rapidly by oxidation under continuous cultivation and cropping. Humus appears to be necessary to keep the soil in good tilth, to stimulate bacterial activity and to maintain its maximum moisture-holding capacity. One or both of these practices, together with proper cultivation, have been found under many conditions not only to aid materially in maintaining the productivity of dry-farm soils but in many cases to be absolutely essential

* The experiment discussed in this publication was outlined by and executed under the direction of Dr. G. W. Shaw, in charge of the Agronomy work until 1913. The field work was conducted under the supervision of Mr. A. J. Gaumnitz, in charge of the experimental work at Davis during the same period of time.

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warm skim milk is fed from this time on until weaning time, at four to five months of age. The time of changing from whole milk to skim milk varies according to the vigor and the value of the calves. It is aimed to bring them on to skim milk soon after two weeks, unless some special reason renders it desirable to continue the feeding of whole milk for a longer period. It has been abundantly proved, both by direct experiments and by the experience of practical dairy farmers, that as thrifty and vigorous calves can be raised on skim milk with proper supplementary grain feeds as on whole milk, and the expense of raising the calves will be reduced to nearly one-fourth by this method of feeding. Direct experiments have shown that the feeding value of whole milk and skim milk for young stock stands in a ratio of about 2 to 1, while the common wholesale or creamery prices of the two products are about 8 to 1.

At the time the calf is put on skim milk diet, it receives a small amount of a grain mixture that is gradually increased from less than one-quarter of a pound daily to about two pounds at weaning time. Bright, fine alfalfa hay or grain hay is also kept before the calves during this period, as well as clean drinking water and salt. The grain mixture for the calves is changed from time to time, according to the special feeds at hand. It is generally composed of standard dairy feeds only, like barley, oats, wheat middlings, dried beet pulp, linseed meal, etc.

CALF-FEEDING TRIALS AT THE UNIVERSITY FARM

The following statement will show the calf-feeding trials conducted during the past two years at the University Farm and reported in this bulletin, with character of grain mixtures fed, length of trials, etc. It will be noted that the following problems have been studied in these trials: The value of linseed meal in various grain mixtures for skim-milk calves; carob pods vs. barley, and dried beet pulp vs cocoanut meal as components of grain mixtures for such calves.

Trial No.	No. of calves included on trial	Grain mixtures fed	Length of trials
I	16	Barley, oats, wheat middlings, with or without linseed meal	Nov. 19, '14–Jan. 28, '15
II	24	Milo and barley, with or without linseed meal	Feb. 4–April 22, '15
III	5	Barley, shorts, linseed meal	May 27–Sept. 16, '15
IV	14	Carob pods and milo vs. barley and milo	Oct. 21, '15–Jan. 20, '16
V	16	Dried beet pulp and barley vs. cocoanut meal and barley	Jan. 27–April 6, '16

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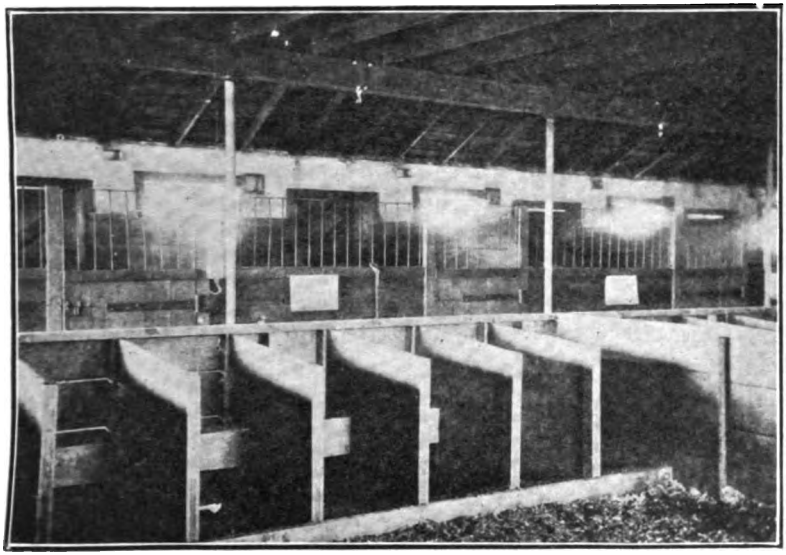

Fig. 1.—Interior of calf barn, rear view of stalls.

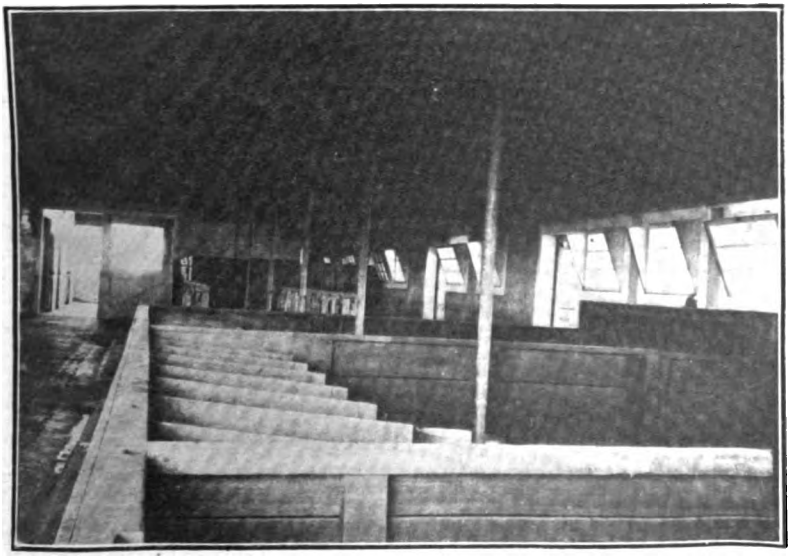

Fig. 2.—Interior of calf barn, side view of stalls.

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The main facts relating to these trials are briefly stated in the following pages, with important results obtained and discussions of the same.

ANALYSES OF FEEDING STUFFS

Samples of the feeds used in the trials reported in this bulletin, except of the skim milk and whole milk, were forwarded at regular intervals to the Nutrition Laboratories at Berkeley for chemical analysis. The kind co-operation of Professor M. E. Jaffa, Chief of the laboratories, in making the chemical analyses and thus aiding in determining the feed components actually consumed by the calves, is gratefully acknowledged. The results of the chemical analyses of the feeding stuffs fed in this and following calf feeding trials are given in Table I, which will also show the digestible components of the various feeds, calculated on the basis of the best available digestion coefficients for the feeds.

PRICES OF FEEDS

The prices at which the various feeds used in the different trials are calculated are given in the following table; they are in most cases average San Francisco market quotations for the five years, 1911–1915, inclusive.

	Per ton	Cents
Barley (rolled or ground)	$29.50	1.5 per lb.
Oats (ground)	34.00	1.7
Wheat middlings	29.50	1.5
Linseed meal	38.50	1.9
Cocoanut meal	27.00	1.3
Dried beet pulp	24.00	1.2
Alfalfa hay	10.50	.5
Milo maize	.....	1.5
Carob pods	.....	1.5
Skim milk	.....	25.0 per cwt.
Whole milk	.....	16.0 per gal.

TRIAL I. Linseed Meal as a Component of Grain Mixtures for Skim-Milk Calves

Whole milk is the ideal feed for calves. It contains all the elements necessary for sustenance and growth, and in the right proportions to secure the best physiological effects. On account of its high value as a human food it can, however, be fed profitably to calves and other young stock, only for a short time, and these are, therefore, ordinarily brought over to a skim-milk diet after the first two or three weeks. The main difference between the two kinds of milk lies in their fat

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COMPOSITION OF FEEDING STUFFS USED ON CALF-FEEDING EXPERIMENTS, 1914–16, IN PER CENT

Name of feed	Laboratory No.	Moisture	Protein	Fat	Fiber	N-free Extract	Ash	Digestible Components Protein	Digestible Components Carbohydrates and fat	Nutr. Ratio
Alfalfa hay	1188	23.00	17.50	2.70	19.55	29.25	8.00			
Alfalfa hay	1208	12.00	14.49	.91	30.86	33.84	7.90			
Alfalfa hay	1210	17.66	13.61	2.22	22.38	36.72	7.41			
Alfalfa hay	1215	15.87	11.32	1.30	28.63	35.85	7.03			
Alfalfa hay	1218	9.95	16.28	1.88	30.68	33.44	7.77			
Alfalfa hay	1295	25.36	13.49	2.73	19.18	33.71	5.53			
Alfalfa hay	1367	13.18	13.88	1.34	23.50	40.66	7.44			
Alfalfa hay	1368	16.43	9.54	1.46	28.81	38.39	5.37			
Alfalfa hay.	1370	16.24	14.88	1.12	18.98	42.35	6.43			
Alfalfa hay	1446	16.95	15.03	2.25	18.32	39.80	7.65			
Average (1914–15)		16.66	14.00	1.79	24.09	36.41	7.05	9.9	38.1	1:3.8
Alfalfa hay	1549	12.80	13.02	2.74	29.84	34.94	6.66			
Alfalfa hay	1552	13.81	12.12	2.01	29.81	35.37	6.88			
Average (1915–16)		13.31	12.57	2.37	29.82	35.16	6.77	8.9	40.2	1:4.5
Rolled barley	1217	12.36	10.37	1.80	6.26	66.61	2.60			
Rolled barley	1369	12.80	10.37	2.35	5.10	66.23	3.15			
Rolled barley	1405	10.38	10.33	2.66	6.76	66.87	3.00			
Rolled barley	1437	13.43	10.39	2.40	5.35	65.63	2.80			
Rolled barley	1484	11.96	8.49	2.35	5.80	68.76	2.64			
Rolled barley	1548	9.50	11.40	2.24	6.55	67.08	3.23			
Rolled barley	1741	13.44	10.33	3.29	5.45	65.11	2.38			
Average		11.98	10.24	2.44	5.90	66.61	2.83	8.0	68.9	1:8.6

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COMPOSITION OF FEEDING STUFFS USED ON CALF-FEEDING EXPERIMENTS, 1914–16, IN PER CENT (*Cont'd*)

Name of feed	Laboratory No.	Moisture	Protein	Fat	Fiber	N-free Extract	Ash	Digestible Components Protein	Digestible Components Carbh & fat	Nutr. Ratio
Rolled oats	1212	15.39	6.62	3.11	7.42	63.65	3.81	5.2	60.3	1:11.6
Milo maize	1441	14.87	6.96	2.78	1.50	71.27	2.62			
Milo maize	1705	9.35	8.98	1.77	2.65	74.52	2.73			
Milo maize	1740	12.30	8.31	1.49	2.20	73.98	1.72			
Average		12.17	8.08	2.01	2.12	73.26	2.36	4.6	59.2	1:12.9
Wheat middlings	1302	8.75	16.35	4.20	3.40	65.15	2.15			
Wheat middlings	1381	11.09	14.67	3.75	5.52	61.03	3.94			
Wheat middlings	1440	12.16	12.34	3.82	3.30	65.23	3.15			
Average		10.67	14.45	3.92	4.07	63.81	3.08	11.1	58.8	1:5.3
Molasses beet pulp	1637	8.50	11.02	.56	10.52	62.27	7.13	6.8	65.1	1:9.6
Linseed oil meal	1300	8.00	34.80	8.50	8.20	34.90	5.60			
Linseed oil meal	1404	9.45	33.60	8.80	8.96	33.69	5.50			
Linseed oil meal	1438	10.05	39.54	8.38	6.03	29.96	6.04			
Linseed oil meal	1483	8.82	36.96	7.96	7.27	32.81	6.18			
Average		9.08	36.20	8.43	7.62	32.84	5.83	32.2	46.8	1:1.5
Cocoanut meal	1547	9.41	21.66	9.50	8.30	45.36	5.77	19.5	62.8	1:3.2
Carob pods	1704	11.91	7.96	1.00	5.60	71.86*	1.67	2.4	66.5	1:27.7
Skim milk ϕ		90.5	3.5	.2		4.9	.9	3.3	5.4	1:1.6
Whole milk ϕ		87.3	3.4	3.7		4.9	.7	3.2	13.2	1:4.1

ϕ Average analyses

* Total sugar 26.90 per cent (sucrose 13.96 per cent., dextrose 12.94 per cent).

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content. Whole milk contains, on the average, 3.5 per cent butter fat, as against .1 per cent or .2 per cent for separator skim milk; the latter is, on the other hand, somewhat higher in protein and in ash, and is lower in milk sugar than is whole milk. As a result, the nutritive ratio (proportion of digestible protein to non-protein) of skim milk is considerably narrower that that of whole milk, viz., 1:1.6 as against 1:4.1. Since whole milk contains the essential feed components in the proportion best suited to the needs of young stock, it may be concluded that it will not be safe to vary greatly from this proportion in substituting other feeds for it, and that a nutritive ratio of about 1:4 will be likely to prove most effective in feeding this class of farm animals.

In changing from whole milk to skim milk for feeding young stock it is necessary to furnish some additional feed or feeds that will supply the deficiency of non-protein substances in the skim milk, viz., either fat, or feed materials of similar physiological effects, like starch or related substances. Feeds of this character available to California farmers are: cereal grains, especially Indian corn, barley and oats; sorghum varieties like milo, kafir, Egyptian corn, feterita; mill feeds like wheat bran and middlings, rice bran (if unadulterated), rice polish, and other factory by-products like dried plain or molasses beet pulp and cocoanut meal. Considering the average market prices for feeding stuffs in this state, Indian corn, oats, and mill feeds are, as a rule, too expensive in comparison with the other feeds named, to be included in grain mixtures for skim-milk calves.

Practical experience has shown that most satisfactory results may be secured in feeding calves by supplementing skim milk with low-protein grain feeds, and it will be noted from the foregoing, that this is based on good theoretical grounds, since the nutritive ratios of such skim-milk rations will approximate that of whole milk. However, mixtures containing medium-protein and even high-protein feeds, like linseed meal, are also frequently fed by dairy farmers. The regular grain mixtures fed to calves at many of the experiment stations and recommended by good authorities are composed of cereal grains with certain proportions of either wheat bran or middlings and linseed meal. Most of the grain mixtures recommended contain from one-sixth to one-eighth of oil meal, and in the proportion in which these mixtures are generally fed with milk and hay, the rations contain considerably more protein and have narrower nutritive ratios than whole milk, viz., on the average, 1:2.5 or 1:3. In view of the difference between this ratio and that of whole milk, and because of the important bearing of the question on general feeding practices

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on the dairy farm, it is of interest to determine whether it is desirable to limit the selection of feeds for calves to farm grains and mill feeds. The experiment reported in the following pages was, therefore, conducted as a preliminary study of calf-feeding problems, with special reference to California conditions.

The experiment was begun November 19, 1914, and continued for ten weeks. Sixteen calves, most of them about a month old at the beginning of the experiment, were separated into two lots that were as uniform as possible as regards previous history, age, weight and breeding. There were seven grade Holstein calves, sired by pure-bred Holstein bulls in each lot, and in addition Lot I contained a pure-bred Holstein bull calf, and Lot II a pure-bred Guernsey bull calf. The calves in Lot I were fed a grain mixture consisting of two parts each of ground barley, ground oats and wheat middlings, and one part of linseed meal, all by weight. Those of Lot II received the same mixture except that no linseed meal was given. The amount of grain fed was gradually increased from one-fourth or one-half pound at the beginning of the trial, to one to two pounds at the close, according to the size and appetite of the individual calf. All calves had been changed to skim milk before the experiment commenced, and this was fed warm from the separator twice a day, in such amounts as they seemed able to consume without scouring, ten to fourteen pounds being fed daily to each calf. In addition, alfalfa hay was supplied twice daily, as much as they would clean up; clean fresh drinking water was likewise given twice a day. All the feed eaten by the individual calves was weighed carefully, except the hay which was weighed out for each lot; this was placed in racks in the two calf pens and the amount eaten was apportioned equally between the calves in each lot. There was naturally more or less hay wasted by this method of feeding, and the amounts credited to the different calves are, therefore, somewhat in excess of what they actually ate, but it is believed that no serious error was introduced in the experimental results by the method of feeding adopted.

The calves in each lot were kept in separate pens, and were fastened with halter straps at feeding time. They were fed skim milk in clean, steamed pails, and the grain mixture was fed in the mangers directly after the skim milk. The calves were left loose in the pens the rest of the time, and were let out into a separate corral for a few hours each day, except in rainy weather. They were weighed for three consecutive days at the beginning and at the close of the experiment, and regularly once a week during its progress, so that the changes in body weight for each animal were followed closely from week to week.

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The trial proceeded without important incidents except that one of the calves in Lot II (Inez, a grade Holstein) often did not take all her milk or grain feed; the gains made by her from week to week varied considerably and were on the whole rather unsatisfactory, viz., 0.57 pounds per day on the average for the whole trial, against 0.93 to 1.53 pounds for the other calves in the same Lot, and 0.86 to 1.47 pounds for the calves in Lot II. The reason why this calf did not do better, is doubtless to be sought in her constitutional weakness, aggravated by

Fig. 3.—Calves in Lot I, Trials I and II.

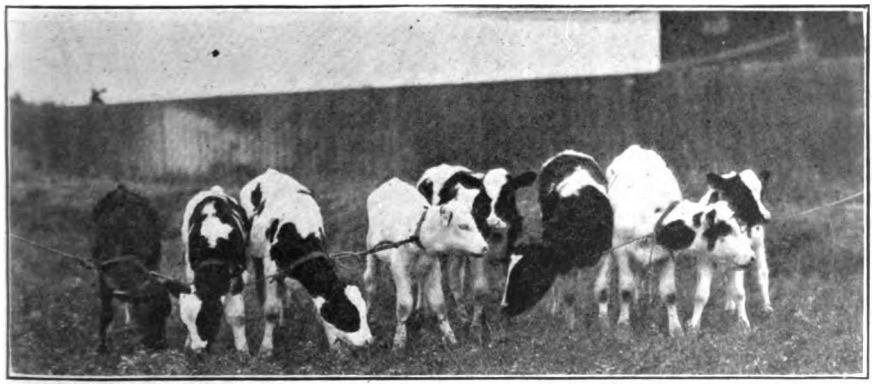

Fig. 4.—Calves in Lot II, Trials I and II.

the fact that she was changed to skim milk at a very early age (when less than two weeks old) and perhaps too rapidly, in order to include her in the trial. Under these conditions it seems fair to omit the results for this calf from the summary of the feed eaten and gains made by this lot. Average figures including data for her are, however, also given in the table in order to make the results secured for all the calves available to those interested. The following summary table shows the main results obtained in the trial:

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SUMMARY OF RESULTS OF TRIAL I

	Lot I Linseed meal	Lot II No linseed meal Av. for 7 calves	Lot II No linseed meal Including Ines
Average age at beginning, days	41	36	33
Weight at beginning, pounds	124.1	124.4	123.1
Average gain per head, pounds	1.13	1.21	1.13
Daily rations fed per head, pounds:			
Grain	.9	.9	.9
Skim milk	11.6	11.8	11.6
Alfalfa hay	2.6	2.5	2.6
Total feed units in rations	4.1	4.1	4.1
Dry matter in rations, pounds	4.06	3.98	4.05
Digestible protein	.74	.71	.71
Digestible carbohydrates and fat	2.17	2.16	2.19
Nutritive ratio, 1:	2.9	3.0	3.1
Dry matter per pound of gain, pounds	3.59	3.29	3.58
Dry matter per pound gained, pounds	3.59	3.29	3.58
Cost of ration, cents	5.7	5.6	5.6
Feed cost per pound of gain, cents	5.0	5.0	4.6

It will be seen that the average rations fed the calves on this trial consisted of nine-tenths of a pound of grain, 11.7 pounds of milk and about 2.5 pounds of alfalfa hay. The rations were gradually increased as the calves grew older. At the beginning of the trial these received from one-half to three-fourths of a pound of the grain mixture per head daily, and 10 to 14 pounds of skim milk. The amounts of hay eaten by the individual calves could not, as already stated, be determined under the conditions of this trial. At the end of the trial the calves each received from 1 to 2 pounds of grain and from 10 to 14 pounds of skim milk daily, the average amount of hay eaten being 3.3 pounds, against 1.5 pounds at the beginning of the trial.

The variations in the average weekly gains in body weight by the calves in the two lots may be seen from the accompanying diagram. It will be noted from the curves for both lots that the gains in weight varied considerably from week to week, and that the calves in Lot II of this trial, on the average, made no gain whatever one week. This also happened once during the second trial; in this case likewise in the case of the lot receiving grain without linseed meal.

The results obtained in this trial indicate that no advantage was gained by including linseed meal in the grain mixture of the calves, in so far as the increase in body weight or the cost per pound of gain is concerned. There was a decrease of nearly 10 per cent in the

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amount of dry matter eaten per pound of gain made by Lot II, as compared with Lot I, and it was noticeable that the calves in the latter lot always ate their grain ration with relish, while the appetites of several calves in Lot II were at times somewhat uncertain. The calves in this lot did not, on the whole, appear to relish their grain as did the calves receiving the mixture containing linseed meal. These also appeared to have a somewhat smoother and more pliable skin, and a more thrifty appearance in general, but the difference was not marked. The calves in Lot II were in excellent condition with the exception of Inez, and made satisfactory gains throughout the trial. Whatever advantage was derived from including linseed meal in the grain mixture was, therefore, slight and the results do not lead to definite conclusions as to the desirability of making linseed meal a component part of the grain mixture for skim milk calves.

TRIAL II. Linseed Meal With Milo and Barley for Skim-Milk Calves

In view of the results obtained in the preceding trial, it was decided to conduct another trial along the same line with a different calf feed mixture, viz, ground barley and ground milo, with or without linseed meal. These feeds were mixed in the proportion of 3:2:1 by weight, for milo, barley and linseed meal (Lot I), and 3:1 for milo and barley (Lot II). Skim milk and alfalfa hay were fed in similar amounts and manner as in the first trial, and the conditions under which this and subsequent trials were conducted were in general similar, so that further details describing these trials will not be necessary. The trial was conducted with the same sixteen calves as in the first trial, and in addition, a third lot of 8 younger calves, one to two months old at the beginning of the trial was included, and was fed the same grain mixture as Lot II, receiving no linseed meal. Of the calves in Lot III, 5 were pure-bred Holstein males, 1 pure-bred Holstein female, 1 female Guernsey grade, and 1 cross-bred male with considerable Angus blood. The trial was commenced February 4th and continued for 77 days, until April 22nd; Lot III was continued on the same system of feeding for another 49 days, until June 4th. Of the calves in Lot II, Inez again showed considerable variation, in appetite and the way she responded to the feeding. She gained on the average .97 pound per day during the trial, against gains of 1.72 pounds to 2.37 pounds for the other calves in the lot, and of 1.84 pounds of 2.32 pounds for the calves in Lot I. It is believed, therefore, that comparison between the two lots, and a study of the effects of

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the two systems of feeding used, should be made after excluding her as before. Data are, however, also given for the entire lot of calves including Inez.

The feeding and care of the calves included in this trial were

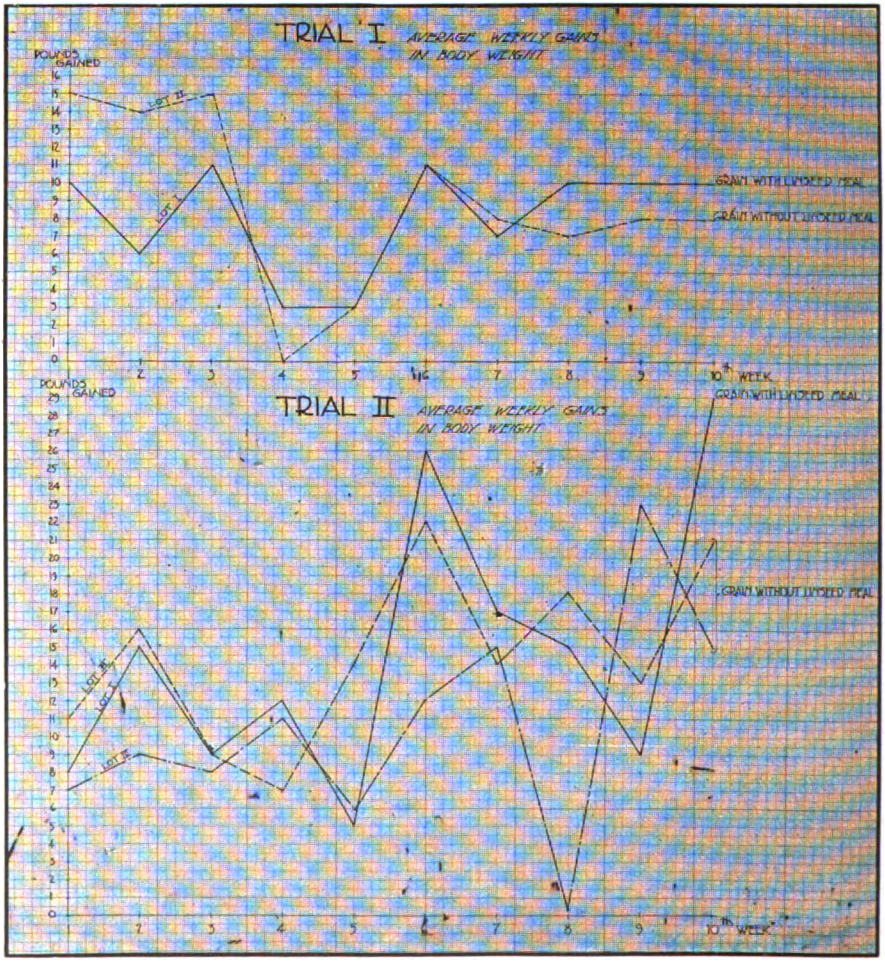

Fig. 5.—Chart showing weekly gains by calves in Trials I and II, fed grain mixtures with or without linseed meal.

entrusted to two senior students in the College of Agriculture, Messrs. W. B. Hubbard and Carl J. Williams, who did this work in a conscientious and very efficient manner, as a part of their thesis requirements for a baccalaureate degree. The following table gives the main facts of the trial.

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SUMMARY OF RESULTS OF TRIAL II

	Lot I (Linseed meal)	Lot II (No linseed meal) Without Inez	Lot II (No linseed meal) With Inez	Lot III (No linseed meal)
Average age at beginning, days	101	95	92	42
Weight at beginning, pounds	200.6	207.3	200.0	126.5
Average gain per day, pounds	2.0	2.03	1.90	1.45
Daily rations fed per head, pounds:				
Grain	2.0	2.0	1.9	.8
Skim milk	11.6	11.4	11.3	11.8
Alfalfa hay	5.5	5.5	5.5	2.8
Total feed units in rations	6.7	6.7	6.6	4.1
Dry matter in rations, pounds	7.45	7.41	7.32	4.15
Digestible protein, pounds	1.13	1.04	1.02	.72
Digestible carbohydrates and fat, pounds	3.93	3.98	3.90	2.21
Nutritive ratio, 1:	3.5	3.8	3.8	3.1
Dry matter per pound of gain, pounds	3.73	3.65	3.85	2.86
Cost of rations, cents	8.8	8.6	8.5	5.6
Feed cost per pound of gain, cents	4.4	4.2	4.5	3.8

The results of this trial point in the same direction as those of the preceding one. There is no appreciable difference in the average data for Lots I and II, as regards the daily gains made by the calves or the amounts of feed eaten; slightly more dry matter was consumed per pound of gain by Lot I than by Lot II, and the cost of the rations fed as well as the gains made were somewhat higher for Lot I. It is, however, safe to conclude from the results obtained in both trials, that linseed meal is not a necessary component of rations for skim-milk calves and does not produce better gains than similar grain rations with linseed meal left out. It does tend, however, to make a grain mixture more palatable to the calves and improves the appearance and handling quality of the calves to some extent. Slightly larger gains were made by the lots in both trials that received a grain mixture without linseed meal, but the difference is too small to be of any importance in either case, being within the limits of experimental errors in trials of this kind.

RESIDUAL EFFECT OF RATIONS

In order to determine whether the feeding of linseed meal produced any residual effect, tending to make the calves stronger and thriftier, so that they would make better gains during the period following the trials than when no oil meal was fed, they were weighed once a month while on pasture after the trial was discontinued, for a period of 160 days. None of the calves received any extra feed during this time.

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The average daily gains of the two lots during this period were as follows:

Lot 1 (linseed meal) 1.60 pounds,
Lot II (no linseed meal) 1.59 pounds.

Here again no appreciable difference was found in the gains made by the two lots; we may conclude, therefore, that whatever advantage may be derived from including linseed meal in the grain ration for dairy calves fed skim milk and alfalfa hay, will come from increasing somewhat the palatability of the feed to the calves and improving slightly the appearance of the latter, and not from any superior nutritive effect of such rations. It is not necessary, therefore, to make this usually high-priced feed a part of the grain ration for thrifty calves that have been successfully brought over to a skim-milk diet.

NUTRITIVE RATIOS OF RATIONS FED

The nutritive ratios of the rations in which linseed meal made up a part of the grain mixture for the calves, were somewhat narrower than those of the corresponding rations without linseed meal; the differences were not marked in any case (1:2.9–3.5, against 1:3.0–3.8), but since the nutritive ratios of the latter rations were always below 1:4, it is evident that no special advantage could be expected from a physiological point of view, from including linseed meal in the grain mixture of the calves. Skim milk and alfalfa hay are both high in protein (nutritive ratio, 1:1.6 and 1:3.8, respectively), and it is not likely, therefore, that sufficient amounts of carbonaceous grain feeds could be fed to render it advisable to include linseed meal in the grain mixture in order to bring the nutritive ratio of the rations down to below 1:4. The sole justification for including linseed meal in calf mixtures will, therefore, be found in the improvement in palatability and dietetic effect that this feed may bring about. Since the market price of linseed meal in this state is, as a general rule, 30 to 40 per cent higher than that of barley and other grain feeds, rations containing linseed meal are more expensive than those without it, and it is a question whether the small benefits that may be derived from including this feed are of sufficient importance to warrant its use, except in the case of less thrifty calves that may need extra care and attention.

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TRIAL III. Barley, Shorts and Linseed Meal for Dairy Calves

The trial was conducted with five calves during the period May 27 to September 16, 1915, the object in view being to secure definite information as to the gains that may be secured by heavy feeding of skim-milk calves. The calves were about two months old at the beginning of the trial and had been changed from whole milk to skim milk shortly before the beginning of the trial; three were pure-bred Holsteins, one grade Holstein, and a Guernsey-Shorthorn grade, there being one male and four females in the lot.

Ground barley, wheat shorts, and linseed meal, in the proportions of 3:2:1 by weight, were fed in addition to alfalfa hay and skim milk. The daily gains made by the different calves during the 112 days of the trial ranged from 2.09 pounds to 2.71 pounds, the average being 2.48 pounds per head. This is a most satisfactory increase in body weight for young dairy calves. The main results obtained in the trial are shown in the following table:

SUMMARY OF RESULTS OF TRIAL III

Average age at beginning, days	69
Weight at beginning, pounds	172.8
Average gain per day, pounds	2.48
Daily rations fed per head, pounds:	
Grain	2.0
Skim milk	14.3
Alfalfa hay	7.3
Total feed units	7.7
Dry matter in ration, pounds	9.47
Digestible protein, pounds	1.38
Digestible carbohydrates and fat, pounds	4.93
Nutritive ratio	1:3.6
Dry matter per pound of gain, pounds	3.82
Cost of ration, cents	10.4
Feed cost per pound of gain, cents	4.2

While the cost of the ration was relatively high, owing to the large amounts of feed eaten, the cost per pound of gain in body weight was lower than for most of the lots fed in the preceding trials. The results of the trial suggest that skim-milk calves can readily be brought up to a weight of over 450 pounds at an age of six months on a ration of skim milk, alfalfa hay, and a suitable grain mixture, at a feed cost of but little over four cents per pound of gain in body weight, from the time they are put on skim milk.

Many dairy farmers consider it the best practice to feed their

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young stock heavily as in this experiment, and thus raise especially large and thrifty calves. There is considerable evidence showing that calves of good breeding fed in this way will develop into very satisfactory dairy cows, with a strong constitution and a capacity for large dairy production. Under this system of heavy feeding the dairy calves must be fed rations rather high in protein substances, like those given in this bulletin, which will produce a strong frame with a good development of body tissue without deposition of excessive fat. We have seen that with skim milk and alfalfa hay there is no danger that the rations fed will not contain an abundance of protein.

TRIAL IV. Carob Pods vs. Barley for Skim-Milk Calves

At the request of Mr. C. W. Beers, Horticultural Commissioner of Santa Barbara County, a feeding experiment with carob pods for calves was conducted during the past fall and winter. These pods are obtained from the carob tree (*Ceratonia Siliqua*), an evergreen tree growing in pastures and waste places in the southern part of the state. It is commonly grown in the coastal regions of southern Europe and on many islands in the Mediterranean Sea, and the pods are highly prized in these countries as a feed for horses, cattle, sheep and swine. They are also used as a human food, somewhat like sugar cane in the south, or for cooking, ground with cereal grains. Their value for feeding purposes depends on the high content of sugar and starch in the pods. The high sugar content in the pods, which in some varieties and seasons reaches 40 to 50 per cent of sucrose and reducing sugars, renders them especially palatable to young stock. According to Pott,[1] "the crushed carob pods are frequently used in England for fattening sheep, and for ewes with lambs, also in connection with other concentrates for fattening steers. It is used in France as a feed for milch cows and young stock, and in southern Italy and other countries as a concentrate for horses and for growing pigs. British horses are at times fed as much as 3 kilos (6.6 pounds) per head, of carobs daily, either cooked and mixed with cut straw, or raw. Fattening steers are also fed preferably cooked carobs towards the end of the fattening period. For horses it is not even necessary to crush the pods. In southern Italy nobody would think of doing it, although the strong pony-like horses do not receive any other concentrates, and are fed only hay or green feed in addition."[2]

[1] Futtermittellehre, Vol. II, part I, p. 453 to 455.

[2] For a discussion of the Carob and its adaptability to conditions in this State, see address by C. W. Beers before the 44th Fruit Growers' Convention at Davis, California, June 1914, in California Farm and Home, July 19, 1914. Chemical analysis in Cal. Exp. Sta., Rept. 1903–4 p. 49.

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The carob tree grows well in this state especially in the southern coastal counties, and may be planted in stony and other waste places. It is reported to yield 300 to 500 pounds of pods per tree when full grown. In view of the favorable reports on the pods from foreign countries, it appeared desirable to secure accurate information as to their value for stock feeding under California conditions. It was thought that the pods might be found especially useful as a constitutent of calf meals and a trial was, therefore, planned with a view to obtaining definite data on this point, especially as to their value when mixed with ground milo in comparison with ground barley and milo, both of which are standard grain crops in this state and may be raised on most of our ranches.

Fourteen calves separated into two lots of eight and six each, were included in the trial; seven of these were from one to two months old, and seven only about a week old at the beginning of the trial. The former were pure-bred Jerseys, Guernseys, Ayrshire and Holstein calves of our own breeding, three males and four females, while the latter were high-grade Holstein female calves bought for this trial. The older calves were changed gradually from whole milk to skim milk during the second and third week of the trial, and the young ones during the fifth and sixth week. The trial was continued for 13 weeks, October 21, 1915, to January 20, 1916. The two lots were fed as follows:

Lot I, Carob pods and ground milo, 1:1 by weight,
Lot II, Ground barley and ground milo, fed in the same proportion.

The calves received from less than ½ to three pounds of the grain mixture per head daily, according to age and capacity; and in addition 14 to 25 pounds of milk and alfalfa hay *ad libitum* (2.3 to 6.1 pounds per head daily).

Some difficulty was experienced at first in preparing the pods for feeding; efforts to grind them in an ordinary feed mill were unsuccessful, as the gummy substances in the pods soon clogged the plates, whether the pods were run through alone or mixed with milo. It was found, however, that the ordinary machinery used in rolling barley or oats would crush the pods so that they could be readily eaten by stock. The pods were flattened and broken into pieces of varying sizes by this method of preparation, and fair proportions of the hard beans were also crushed or flattened in the process of rolling. The pods thus prepared were mixed in equal proportions by weight with ground

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milo and fed to Lot I. The calves relished the pods greatly, and as a rule, ate them before the milo. The main results of the trial are summarized below:

SUMMARY OF RESULTS OF TRIAL 1V

	Lot I Carob and Milo	Lot II Barley and Milo
Average age at beginning, days	28	30
Average weight per head, pounds	131.8	116.7
Average gains in body weight per day, pounds	1.81	1.70
Average ranges in daily gains, pounds	1.67–2.03	1.32–2.09
Daily rations fed per head, pounds:		
Grain	.8	.7
Whole milk	5.0	4.5
Skim milk	14.2	13.3
Alfalfa hay	2.6	2.6
Average rations contained, pounds:		
Dry matter	4.86	4.62
Digestible protein	.92	.89
Digestible carbohydrate and fat	2.93	2.75
Nutritive ratio, 1:	3.2	3.1
Total feed units in ration	6.2	5.7
Dry matter per pound of gain, pounds	2.69	2.72
Cost of rations, cents	16.1	14.8
Feed cost per pound of gain, cents	8.9	8.7

While the composition of the average rations fed to the two lots varied somewhat, it is evident from the results obtained that the carob-milo mixture had at least a similar feeding value to the barley-milo mixture. The lot fed the former mixture gained an average of 1.81 pounds per head daily during the trial, against 1.70 pounds for the the barley-milo mixture. The average gain in the body weight for the older calves (50 days old at the beginning of the trial) was for Lot I, 1.90 pounds, and for Lot II, 1.74 pounds; for the younger calves (7 days old at the beginning of the trial), Lot I, 1.72 pounds, Lot II, 1.65 pounds. The cost of the rations fed and the average feed cost per pound of gain were higher than in the preceding trials, for the reason that considerable whole milk was fed during the first half of the feeding period, the calves included on the trial being younger than in the earlier ones. If only the second half of the trial be considered, when the ration fed consisted of grain, hay and skim milk, the results would come as follows:

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	Lot I	Lot II
Average age at beginning, days	64	66
Average body weight at beginning, pounds	191.2	169.8
Grain per head, pounds	1.87	1.79
Rations fed, pounds:		
Grain	1.1	.9
Skim milk	19.6	18.4
Hay	3.8	3.8
Cost of rations, cents	8.5	7.9
Feed cost per pound of gain, cents	4.5	4.4

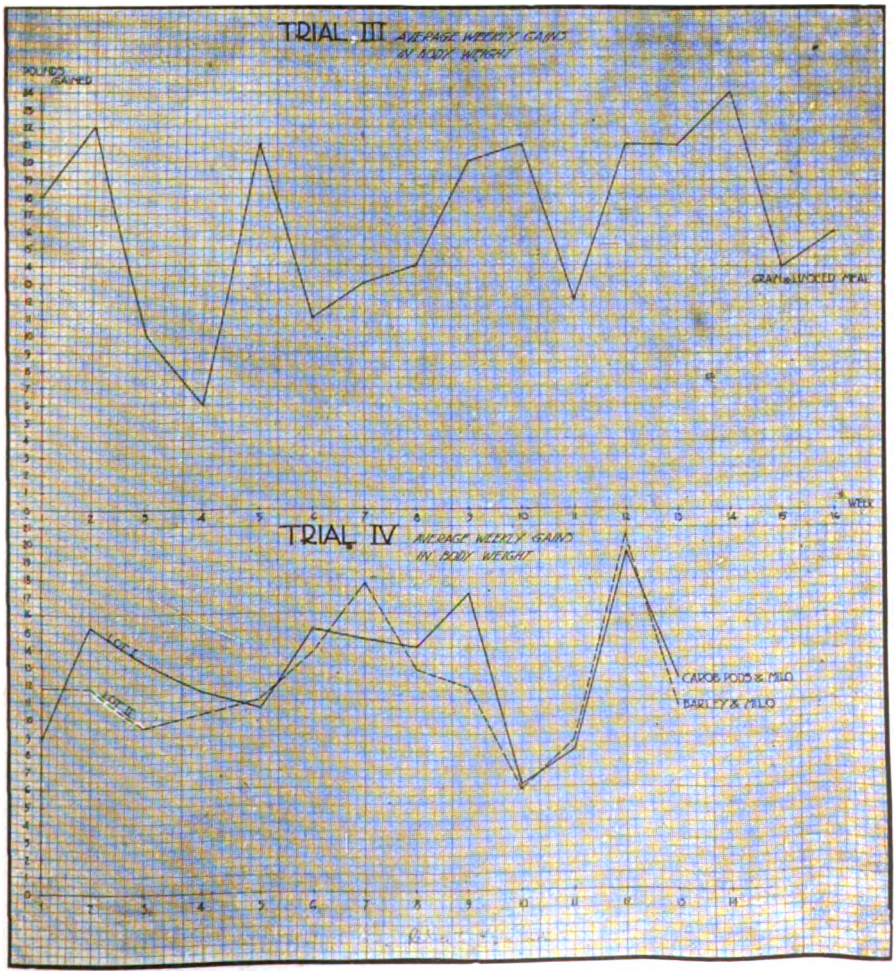

Fig. 6.—Chart showing weekly gains by calves in Trials III and IV, fed grain and linseed meal, and carob pods and milo vs. barley and milo, respectively.

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Whether the data for the entire feeding period are considered or only those for the latter half, when no whole milk was fed, the same conclusion may be drawn from the results, viz., that the nutritive effect of the carob-milo mixture was fully equal to that of the barley-milo mixture, or the carob pods may be considered of similar value to barley, at least as a feed for calves.

There is no marked difference in the chemical composition of these two feeds, as will be noted from the analysis given on pp. 23–24 of this bulletin. The digestibility of carob pods has been determined in four trials (with two different samples); the average digestion coefficients obtained show a relatively low digestibility of the protein substances (34 per cent), and a medium digestibility of the fat (56 per cent). Eighty-six per cent of the nitrogen free-extract (sugar, starch, etc.) were, however, found to be digestible, and since these substances make up nearly three-fourths of the weight of the pods, the nutritive effect of these will depend almost wholly on their contents of digestible carbohydrates. The average digestible components in the carob pods are: protein 2.4 per cent, carbohydrates and fat 66.5. per cent (nutritive ratio, 1:27.7; see page 24); while the corresponding figures for the barley fed in the trial were 8 per cent and 68.9 per cent (nutritive ratio, 1:8.6 per cent). It would appear from the results of this trial that the digestibility and the nutritive effect of the carob pods are somewhat higher than are indicated by the available average data for this crop.

The results of the trial described in the preceding pages indicate that carob pods make a very valuable component of a grain mixture for skim-milk calves, and to this extent at least they corroborate European feeding experience with this feed. If the carob tree will thrive in certain sections of the state, like the central and southern coastal counties, as appears to be the case, then farmers in this region may well plant the tree on non-arable land, in pastures, hill-sides and stony places, etc., and thus in time be able to secure a regular supply of a highly palatable and valuable feed for their stock, without further effort and expense than the harvesting of the fruit.

TRIAL V. A Comparison of Dried Beet Pulp and Cocoanut Meal for Dairy Calves

Both dried beet pulp and cocoanut meal are common dairy feeds in this state. They are generally fed to dairy cows and fattening steers, and in the case of cocoanut meal, at times to pigs and horses; but little is known in regard to their value for feeding dairy calves,

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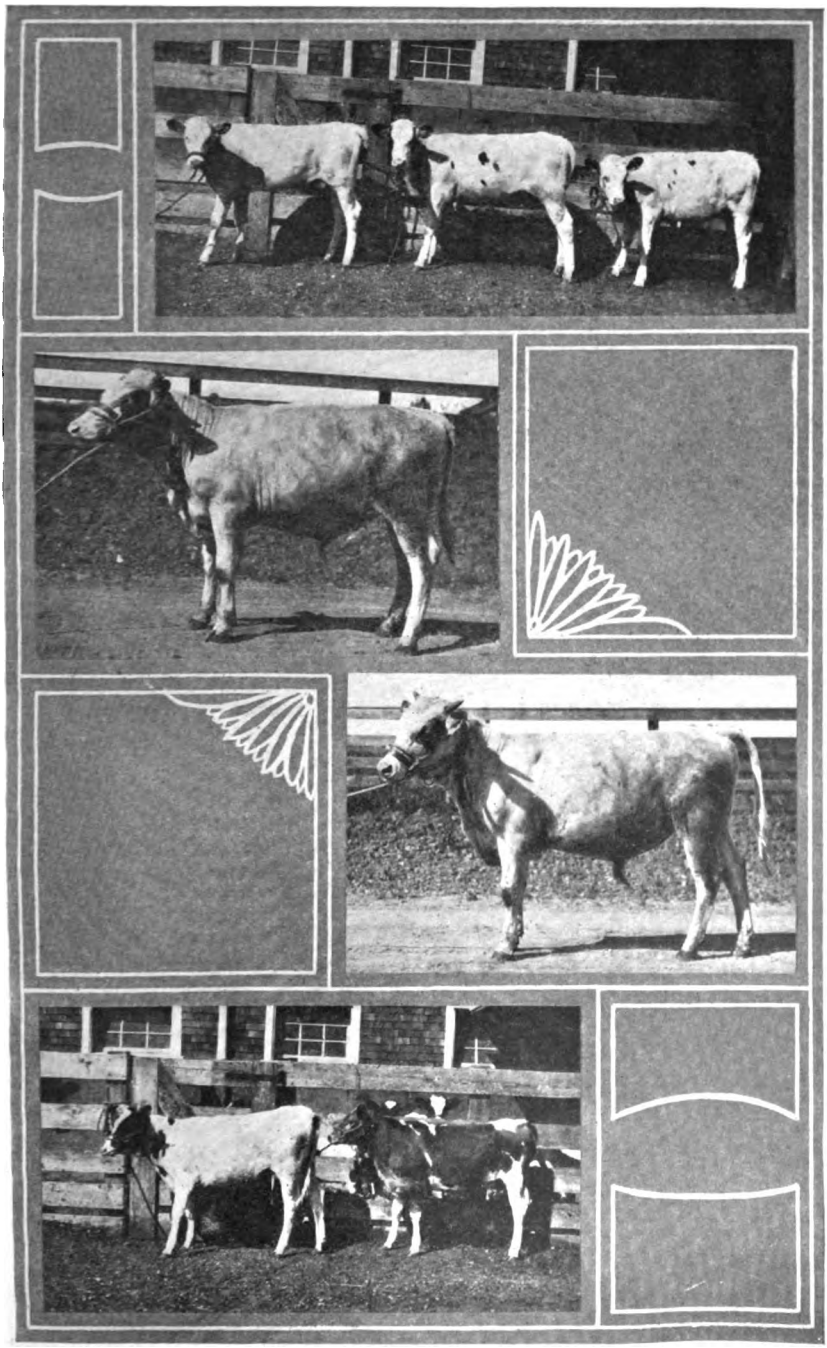

Fig. 7.—Calves in Trial V, Lot I, at the close of experiment.

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and an experiment intended to furnish information on this point was accordingly planned. The fourteen calves in the preceding trial were continued on this one, a week's intermediate feeding being introduced in order to accustom them to the ration to be fed in this trial. The grouping of the calves into two lots was changed from that of the preceding trial so as to guard against any residual effect of the previous system of feeding on the results of the trial. Lot I was fed two parts rolled barley and one part dried beet pulp, while Lot II received two parts rolled barley and one part cocoanut meal, in both cases by weight. All calves were fed separator skim milk and alfalfa hay, in addition to the grain mixtures, until February 24 to March 9, when six of the older calves, three in each lot, were gradually weaned, and these received only dry feed after March 9.

The calves ranged in age from 93 to 171 days at the beginning of the trial, the average age of those in Lot I being 122 days and those in Lot II 123 days. This trial was arranged for as thesis work for two senior agricultural students, Messrs. C. V. Castle and W. F. Elder, who had charge of the feeding and care of the calves during the experimental period. Much credit is due to these students for the careful and conscientious manner in which their work was done. The most important data obtained in connection with the trial are shown in the following statement.

SUMMARY OF RESULTS OF TRIAL V

	Lot I Beet pulp and barley	Lot II Cocoanut meal and barley
Average age at beginning, days	122	123
Average weight per head, pounds	287.1	280.9
Average gains in body weight per day, pounds	2.08	1.84
Average ranges in gain, pounds	1.50–2.41	1.54–2.00
Daily rations fed per head, pounds:		
Grain	2.3	2.2
Skim milk	14.4	13.7
Alfalfa hay*	10.1	9.7
Average ration contained, pounds:		
Dry matter	11.77	11.28
Digestible protein	1.55	1.58
Digestible carbohydrates and fat	6.39	6.10
Nutritive ratio, 1:	4.1	3.9
Total feed units in ration	9.7	9.3
Dry matter per pound of gain, pounds	5.66	6.13
Cost of ration, cents	12.1	11.6
Feed cost per pound of gain	5.8	6.3

* No allowance made for waste in feeding hay.

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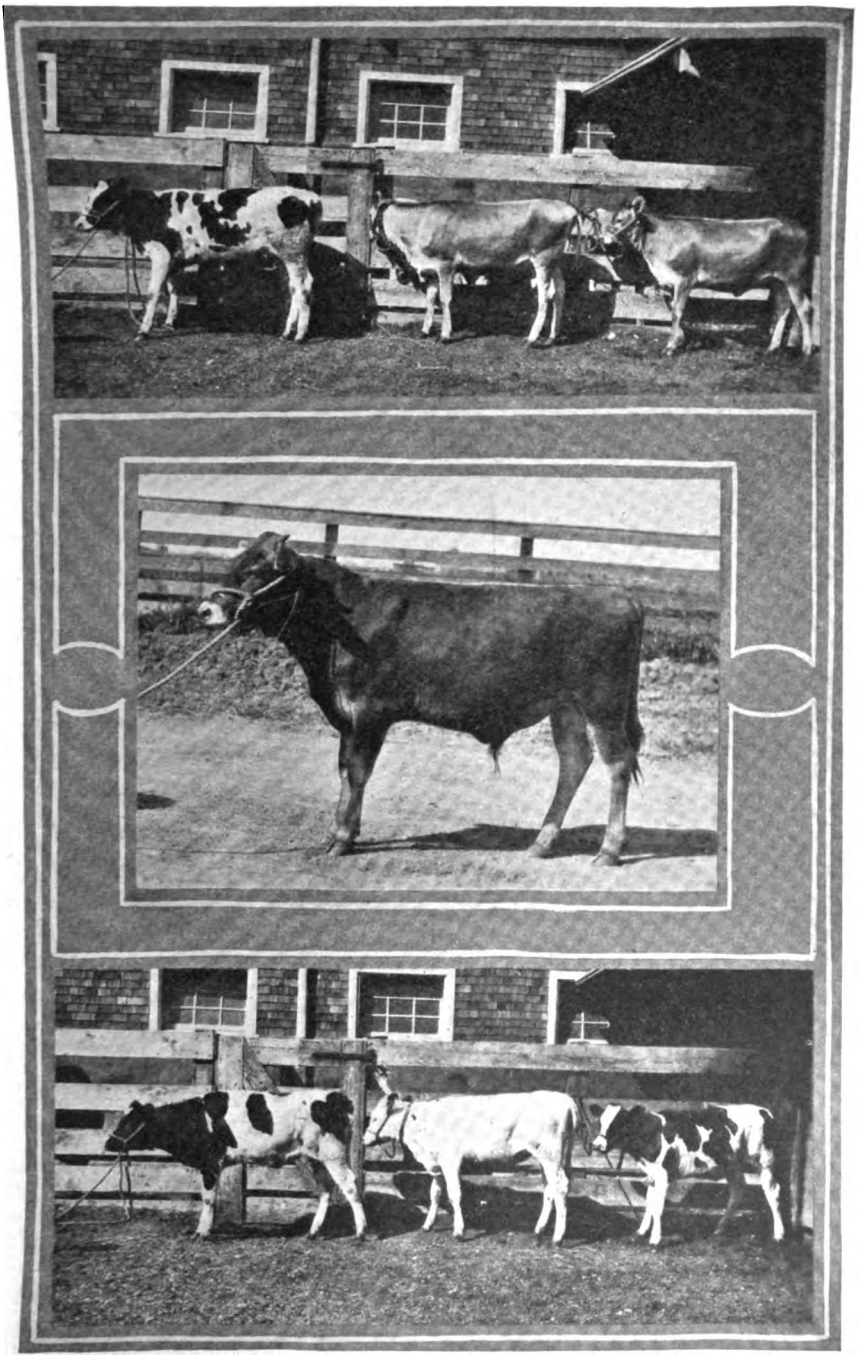

Fig 8.—Calves in Trial V, Lot II, at close of experiment.

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In this, as in the other trials reported in the preceding pages, no allowance was made for waste in feeding the hay in racks in the calf pens. This waste was apparently of greater importance in the case of the older calves on this trial than in the earlier ones. Under the conditions stated the amounts of hay given and the composition of the rations fed are mainly of value for comparison of the results obtained with the two lots; the figures given cannot be taken to represent the exact amounts of hay or of digestible components in the rations actually eaten by the calves.

The calves included in the trial gained, on the average, as follows in body weight: Lot I (dried beet pulp and barley) 2.08 pounds per

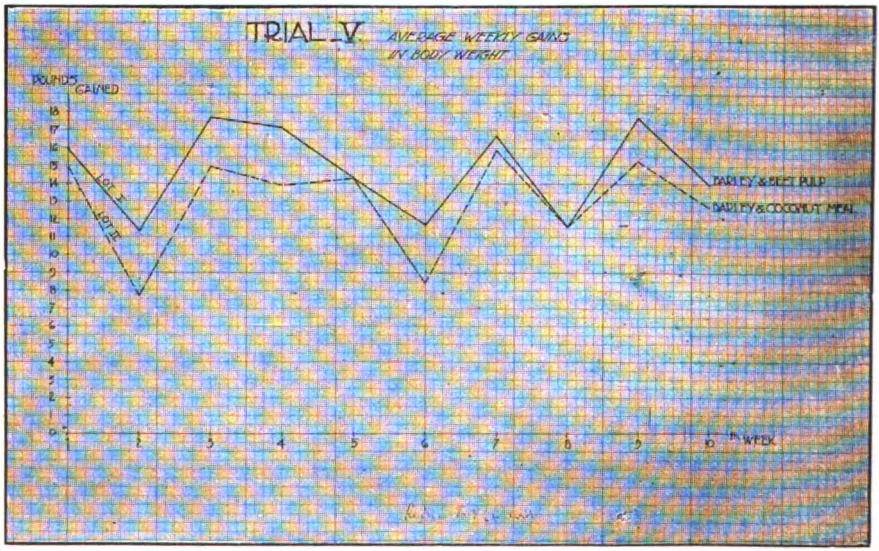

Fig. 9.—Chart showing weekly gains by calves in Trial V, fed beet pulp and barley vs. cocoanut meal and barley.

head daily and Lot II (cocoanut meal and barley) 1.84 pounds. Only one of the calves in the former lot gained less than two pounds daily, on the average for the 70 days of the trial, while six of those in Lot II gained less than two pounds. The average amounts of feed eaten by the calves in the two lots did not differ materially. It is evident, therefore, that the nutritive effect of the beet pulp-barley mixture fed with skim milk and alfalfa hay was somewhat (viz., about 10 per cent) higher than that of the cocoanut meal fed in similar amounts and combinations. The results of the trial indicate that both these concentrates fed, as stated, to dairy calves, will produce satisfactory gains in body weight. Both rations proved palatable to the calves.

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The cocoanut meal had a tendency to cause scouring in the case of some of the calves; it is also, as a general rule, somewhat higher in price in this state than dried beet pulp; as it moreover did not produce as good gains as the latter feed, there is no reason for feeding it to skim milk calves in preference to dried beet pulp or other equally satisfactory grain feeds that can be obtained at a similar or lower cost.

As beet pulp and cocoanut meal are ordinarily two of the cheapest dairy feeds available to our farmers, and as both produce very satisfactory results in this trial, either may, however, be recommended for feeding dairy calves whenever it seems desirable to give variety to the grain mixture fed. The grain feed used in this trial (two parts of barley to one of either of the concentrates mentioned) may be fed when barley is relatively cheaper than the two other feeds; otherwise a proportion of equal weights of barley and beet pulp, or better still, a mixture of barley, beet pulp and cocoanut meal in the proportions 2:1:1 may be fed. This will make an excellent grain ration, especially for older skim-milk calves, it being both palatable and cheap at ordinary feed prices in this state.

GENERAL DISCUSSION OF FEEDING DAIRY CALVES

The results of the five feeding trials with dairy calves reported in the preceding pages show that vigorous, thrifty calves, of very satisfactory body weights, can be readily raised on separator skim milk, grain feeds and hay. It is, as a rule, only necessary to feed whole milk during the first two weeks of the calf's life, and the expense of raising the calf may thus be kept down to a minimum. The young calf should receive 10 to 20 pounds of milk daily, according to size and thriftiness, and a small amount of a grain mixture is fed from the time it is brought over onto skim milk, viz., less than ¼ pound daily for calves only a couple of weeks old, to 2 or 3 pounds toward weaning time at four to five months old. The grain mixture should consist of starchy concentrates or of such as are low in protein, like rolled barley, oats, wheat bran or middlings, milo, kafir, Indian corn, dried beet pulp, cocoanut meal, crushed Carob pods, etc.; in the case of more or less delicate calves that do not eat their feed readily, a small proportion of linseed meal may be included in the grain mixture. Indian corn, oats and middlings are ordinarily too expensive to be used for feeding calves under our conditions. A fine quality of clean bright hay should be placed before the calves

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twice daily, in addition to skim milk and grain, in such amounts as they are likely to clean up.

Only heifer calves from the best cows in the herd should be raised to be added to the herd, since calves from other cows will not be likely to develop into profitable dairy cows. Calves not raised for the dairy herd may be fed for veal and disposed of at about two months of age or later. Whole milk can only be fed with profit during all or most of this time when a special price can be obtained

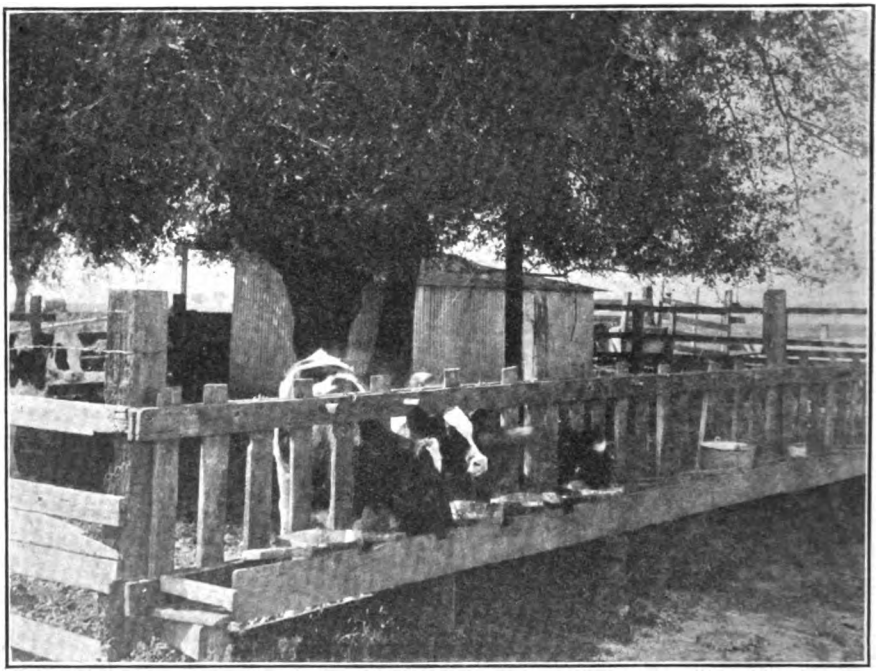

Fig. 10.—Home-made calf stanchions.

for a superior article. Such markets are rarely found outside of the large cities, and even there the demand for choice veal is limited, although increasing. Most calves that are to be vealed must, therefore, be fed skim milk after the first couple of weeks; some farmers allow veal calves to run with the cows, generally placing two calves to a nurse cow, or continue the feeding of whole milk along with skim milk until the calves are sold, but this method increases considerably the cost of the ration. It is not necessary to feed whole milk for making an excellent quality of veal; and this can be produced on skim milk supplemented with suitable grain feed and hay, as above

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suggested. The method of feeding in this case does not differ from that of raising skim-milk calves for the dairy, except that the calves are fed all the grain they will eat with relish, so at to insure rapid gains in weight. Good veal calves weighing 200 pounds or more may be sold at say two months of age, at a feed cost below $8 a head, figured at current market prices. The production of veal calves under the conditions stated, should form a profitable sideline for the dairy farmer, and calls for but little extra effort beyond providing clean sanitary quarters for the calves and feeding them plenty of wholesome nutritious feeds. Cleanliness and regularity in feeding are most important factors in successful calf raising.

If it is desired to feed the calves for a longer period than two months, good and economical returns may be received for the feed eaten, by continuing the system of feeding outlined. If the calves are dropped in the fall or winter, they may be put on pasture in the spring, and cheap gains made by feeding a few pounds of grain daily per head in addition, so as to keep them in a growing thrifty condition. It will be advisable to dispose of them before they are a year old, however, when they should weigh 600 pounds or better. So-called baby beef, a trade term for 15 to 18 months old steers, weighing 1000 to 1200 pounds, can only be raised from young beef-bred stock of a blocky type and inbred capacity for a large feed consumption and a rapid growth.

One of the common causes of failure in raising calves, is that of over-feeding, which usually results in scouring. When scouring occurs, the amount of milk fed should be immediately reduced, or in severe cases no milk is given until the trouble ceases. If no improvement follows, special means must be taken to stop the scouring. There are a number of remedies for this trouble that may usually be applied with satisfactory results. One of the simplest is castor oil, two tablespoonfuls being given with the milk or alone, once a day. Another remedy is a weak solution of formaldehyde. A stock solution is made up on one-half ounce of commercial formaldehyde added to one pint of water, and a teaspoonful of this solution is given in the milk per pint of milk. Blood meal will also often prove effective, being stirred into the milk in the proportion of a teaspoonful per feed; this is also a good tonic for weak young calves. The so-called Soluble Blood Meal or Blood Flour is preferably used for this purpose.

When skim milk cannot be obtained, it will be necessary to feed whole milk until the calves are sufficiently strong and thrifty to do well on a gruel of ground grain and mill feeds, at about three or four

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weeks old. It is a difficult undertaking to raise very young calves successfully without milk and calls for constant care and watchfulness on the part of the feeder. Commercial calf feeds will give satisfactory results in some cases, but are relatively expensive. The following home-made mixture for young calves may be recommended under the conditions prevailing in our state: rolled or ground barley, oats, wheat middlings, and linseed meal or flaxseed meal, two parts of the first three feeds and one part of linseed meal, or of ground flaxseed, if this can be obtained at a reasonable price, say within a few dollars of the price of linseed meal per ton.

As suggested in the introduction to this bulletin, progress in dairying depends to a large extent on farmers raising the heifer calves from all the good cows in their herds. Only in this way can, they take advantage of the improvement in the production of the herd which they have been able to reach, and maintain a high production in their herd. The purchase of mature pure-bred bulls or of heavy-producing cows is not possible for most dairy farmers, although no farmer can expect to make a success of dairying unless he places at the head of his herd the best pure-bred dairy bull that he can secure. It is a trite but true saying among breeders, that the bull is half the herd; he transmits to his offspring the capacity for a large dairy production that has been bred into him for many generations back, and is, therefore, likely to be worth all that he costs, and more; but cows of good or exceptional productive capacities are rarely for sale, except perhaps at fancy prices. Each farmer is, therefore, as a rule dependent on his own supply of calves for maintaining or increasing the production of his herd. Calves not intended to be added to the herd should be raised for veal. The data presented in this bulletin as to methods and results obtained in feeding various common feeds available in this state to dairy calves have shown how the latter can be raised successfully and profitably, either for the dairy herd or for veal. These discussions should prove of assistance to farmers in their efforts toward improving the production and the returns secured from the dairy herd.

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BERKELEY, CALIFORNIA

Commercial Fertilizers

By P. L. HIBBARD

BULLETIN No. 272

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COMMERCIAL FERTILIZERS.

By P. L. Hibbard.

This bulletin comprises the results of the fertilizer inspection work of the California Fertilizer Control for the fiscal year ending June 30, 1916.

Purpose and Functions of the Fertilizer Control.

The duty of the Fertilizer Control is:

First: To issue certificates of registration to manufacturers and dealers who have complied with the law by filing a sworn statement of composition and sources of the fertilizers they wish to sell.

Second: To analyze these fertilizers as found in the open market and publish the results for the information of the public. If a manufacturer sells fertilizers which are materially below his guarantee in composition or value he is subject to prosecution and fine. By this means it is intended to insure to purchasers that the fertilizers they buy shall be substantially as good as represented.

By a study of the reports of analyses of fertilizers, the consumer should be able to determine whether the materials he buys are sold for a fair price, and whether he obtains fertilizers of the desired composition. In short, the function of the Fertilizer Control is to see that the manufacturer gives the consumer a square deal.

Maintenance of Guarantees.

Every manufacturer is required by law to guarantee the percentage of nitrogen, phosphoric acid and potash in the fertilizers he sells. Owing to difficulties of sampling and analysis the law permits a maximum deficiency of 0.25% nitrogen, 1.00% phosphoric acid, 0.50% potash from the figures guaranteed. Greater deficiencies than these are regarded as infractions of the law, for which the manufacturer may be prosecuted and fined. Such deficiencies are indicated in the report of analyses in black face type.

Some manufacturers uphold their guarantees better than others. The following table is a condensed report of the deficiencies found in the main table of analyses. It summarizes the work done in this laboratory on each manufacturer's goods. The columns headed Deficiencies—per cent of possible, may be used for comparison of the various companies as to probability of meeting their guarantees. The other columns are necessary to show how these figures were obtained. In cases where very few analyses are reported for a manufacturer, the figures should be taken with caution, as perhaps not properly representative. When several samples of one manufacturer's goods were

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analyzed the figures may be accepted as probably a fair indication of the reliability of his guarantee.

In general, manufacturers have more than maintained their guarantees, so that an average of all the analyses would show a substantial increase over the amount guaranteed.

This table is a condensed statement of the performances of each company during the fiscal year 1915-16, and as such may be an indication of what may be expected in the future. A manufacturer who maintained his guarantees well last year will probably do the same this year.

Maintenance of Guarantees by Manufacturers.

Manufacturer	Number of brands sampled	Number of samples analyzed	Total number of guarantees on samples analyzed	Deficiencies			
				In guarantees		In valuation	
				Number	Per cent of possible	Number	Per cent of possible
Agricultural Chemical Works	21	58	151	9	6.0	3	5.3
American Agricultural Chemical Co.	6	24	72	0	0.0	0	0.0
Armour Fertilizer Works	28	139	294	15	5.1	9	6.6
Rogers Brown & Co.	2	3	6	2			
California Fertilizer Works	3	5	12	1	8.3	0	0.0
Cudahy Packing Co.	9	14	19	4	21.1	1	11.1
Diamond Fertilizer Co.	1	9	18	0	0.0		
Duff's Fertilizer Co.	3	3	3	0	0.0	1	
General Fertilizer Association	12	19	52	13	25.0	5	31.2
Germain Seed and Plant Co.	1	2	4	0	0.0	0	0.0
Globe Grain and Milling Co.	1	1	3	0	0.0		
Hauser Packing Co.	6	30	56	3	5.4	1	3.8
Hawaiian Fertilizer Co., Ltd.	10	10	23	0	0.0	0	0.0
Los Angeles Fertilizer Co.	2	2	5	1	20.0	0	0.0
Mountain Copper Co.	2	3	5	0	0.0	0	0.0
Nitrate Agencies Co.	1	2	2	0	0.0	0	0.0
Oakland Meat and Packing Co.	1	2	2	0	0.0	0	0.0
Pacific Bone, Coal and Fertilizing Co.	7	17	29	2	6.9	1	6.6
Pacific Coast Beef and Provision Co.	1	1	2	0	0.0	0	0.0
Pacific Guano and Fertilizer Co.	11	21	45	2	4.4	1	4.8
Pacific Reduction Co.	1	7	21	1	4.8		
Redlands Fruit Association	1	1	1	0	0.0	0	0.0
Swift & Co.	1	1	2	0	0.0	0	0.0
Union Fertilizer Co.	3	13	37	0	0.0	0	0.0
Union Superphosphate Co.	1	1	1	0	0.0	0	0.0
Western Fertilizer Co.	1	3	9	5			
Western Meat Co.	16	76	153	17	11.1	7	9.3

Owing to the possibility of misunderstanding, the figures for percentage deficiencies are not given in above table in cases where less than 4 samples were analyzed.

Fertilizers sold on Station analysis, and some others, are not given a valuation in the table of analyses, hence the number of such samples is deducted from the total number analyzed, in computing deficiencies in valuation.

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Mechanical Condition of Fertilizers.

A good degree of fineness is one of the essential qualities of a good fertilizer. It may be assumed as generally true that the finer the material the higher the availability, hence the consumer should insist on having finely ground fertilizers. Unfortunately some manufacturers are at times careless in regard to the fineness of their goods. The insistent demand of the consumer is the most effective means of correcting such carelessness.

Besides the low agricultural availability and the difficulty in applying coarse fertilizers, it is almost impossible to obtain a satisfactorily representative sample of such goods for analysis. This is a prolific source of dissatisfaction and disagreement between buyers and sellers. During handling and transportation a coarsely ground tankage will separate so that the top of the sack contains the coarser material, high in nitrogen, while the bottom contains the finer parts of bone, high in phosphoric acid. A mixture of coarse bone meal with sulfate of potash will separate into coarse bone at the top and excess of potash at the bottom.

One of the chief reasons for the existence of the fertilizer manufacturer is that he is better prepared than the farmer to grind and mix the goods he sells, and the farmer should insist that he do it well.

Caution in Regard to Labeling Fertilizer Packages.

The law expressly states that every package of fertilizer shall be accompanied by a plainly printed label giving the brand name, analysis, and source of the materials in the package. This requirement is not satisfactorily met by some manufacturers and dealers. Farmers are hereby cautioned that if they buy improperly or inadequately labeled fertilizers or goods not sold by properly registered dealers or their authorized agents they may lose the protection afforded by the Fertilizer Control. Consumers should insist that fertilizer tags show plainly both the percentage and the derivation of each ingredient. A verbal statement given by the selling agent should not be accepted as adequate. The honest manufacturer is willing to guarantee his goods properly, and the farmer will best serve his own interest by dealing with no other.

Proper Basis for Buying Fertilizers.

For the purpose of this discussion, a fertilizer is a material furnishing plant food, specifically, nitrogen, phosphoric acid or potash. Lime, gypsum, humus, etc., are often of great use in improving crops, but they are not to be regarded as fertilizers in the sense here meant.

Now, if the farmer will realize that in buying fertilizers he is really buying nitrogen, phosphoric acid, or potash, nothing else, he will have

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the only solid basis on which to calculate the commercial value of the goods purchased. He should pay only the fair market price for value received. Consequently the price should depend entirely on the amount of plant food. The amount of plant food can be found in only one way, by chemical analysis. Therefore, the price should depend on the result of chemical analysis. In the language of dealers, this is known as buying on the *unit basis*. A dealer buys 100 tons of tankage guaranteed to contain 8 per cent of nitrogen and 8 per cent of phosphoric acid, at a price of $3.40 per unit for the nitrogen and 90 cents per unit for the phosphoric acid. This makes it cost $34.40 per ton. But if the analysis shows 7 per cent nitrogen and 10 per cent phosphoric acid, on the same basis, the cost would be $32.80 per ton. In other words, the dealer pays for just what he gets in plant food, and for nothing else. The farmer should buy on the same basis. In buying on the unit basis the farmer should escape the high price of plant food usually paid for it when buying low-priced fertilizers by the ton. The farmer should avoid the dealer who is not willing to sell on the unit basis.

Deficiencies.

In the analyses of the above samples, the following number of deficiencies greater than allowed by law occurred:

Available phosphoric acid (total when available is not guaranteed)	21
Total nitrogen	46
Potash	8
In valuation	33

These deficiencies were found in 63 samples.

The fertilizer law allows a deficiency of 0.25 per cent in nitrogen, 0.50 per cent in potash, and 1 per cent in available phosphoric acid.

Fertilizer Valuations.

The calculations of the commercial values of the fertilizers here reported are made on the so-called unit basis. Such calculations consist simply in multiplying the number of per cent of each ingredient by the price per unit and adding the products. The sum thus obtained is the commercial value per ton at the prices used. If it is desired to use such a calculation for determining the amount which should be paid for goods, or the rebate to which the buyer is entitled owing to the goods delivered being below the guaranty, it can only be satisfactorily done if a definite price per unit has been agreed upon between buyer and seller. But for the mere purpose of showing the relative values of goods to guaranties, it is not at all necessary that the prices adopted should be the exact market prices. Thus it is that the Fertilizer Control in attempting to show the relation between values found

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and values claimed, uses a schedule which is admittedly only an approximate average of market values. Owing to market fluctuations, differences in cost of delivery at different points, and other causes, the obtaining of true average market prices is an impossibility. But if the reader will bear in mind the true purpose of the valuations reported, these will have served their turn and he will not be led to assume that the Experiment Station is dictating the prices at which goods shall be sold. Valuations thus construed should serve two purposes.

(*a*) To show whether a certain fertilizer is commercially worth its cost.

(*b*) As a measure for comparing the commercial values of different brands, thus enabling the buyer to select that brand which will give him the greatest value for the money he spends.

Schedule of Trade Values, 1916–17.

	Pound.	Unit.
Nitrogen from blood	$0.23	$4 60
Nitrogen from tankage and bone	.22	4 40
Nitrogen from sulfate of ammonia	.19	3 80
Nitrogen from nitrate of soda	.19	3 80
Nitrogen from nitrate of lime	----	----
Nitrogen from cyanamid	.16	3 20
Nitrogen from cottonseed meal	.22	4 40
Phosphoric acid from bone super	.05	1 00
Available phosphoric acid from rock super	.047	94
Total phosphoric acid from Thomas phosphate	----	----
Total phosphoric acid from bone meal	.045	90
Total phosphoric acid from tankage	.035	70
Potash from sulfate	.05	1 00
Potash from muriate	.05	1 00

These prices are intended to represent approximate *wholesale* cost of unmixed fertilizer materials at California freight terminals. Besides this, *retail* prices must include cost of mixing, transportation, storage, selling, long credits, bad debts, etc.

Present market quotations of high-grade potash salts are much above those here given; but as these materials are now practically not obtainable for fertilizer purposes, it seems advisable to use about the same figure that prevailed before the present disturbance began, for calculating the value of the small amounts of potash in mixed goods.

Scope of Inspection.

During the year 507 samples of fertilizers and fertilizing materials have been received at this laboratory. Of this number 25 were sent by farmers under the two-dollar fee provision, 174 were taken by inspectors from purchasers' goods upon the request of the purchasers, and 283 were taken by inspectors from goods in the hands of agents

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and manufacturers. On 17 samples the analysis as reported was used as a basis of settlement by mutual agreement of buyer and seller.* No guaranty was required or given with goods sold under such agreement. Twenty-five samples of a miscellaneous nature are omitted from the tables.

The following classification may be made of samples reported in this bulletin:

Bat guano	4
Blood	56
Bone meal	49
Complete fertilizer	195
Cottonseed meal	1
Cyanamid	2
Garbage tankage	22
Nitrate of soda	12
Nitrate of soda and bone	1
Rock phosphate	1
Rape seed meal	1
Superphosphate	8
Tankage	115

Registered Manufacturers and Dealers.

The following manufacturers and dealers in commercial fertilizers have obtained certificates of registration under the provisions of the California fertilizer law, for the fiscal year beginning July 1, 1915. A list is also given of the brands of fertilizers and fertilizer materials offered for sale by them. According to the sworn returns of dealers registered for the fiscal year ending June 30, 1915, their entire sales in the state amounted to 31,540 tons. Incomplete returns for the year ending June 30, 1916, indicate approximately 29,000 tons.

No dealer or manufacturer, except those who have certificates of registration from the University of California, and their authorized agents, can legally sell fertilizers in this state. No person or company has any right to use any registration number except in connection with the firm name to which the registration certificate of such number has been issued; and no person or company to whom a registration number has been assigned has any right to give any other person or company permission to use said registration number, and any number so used is a fraud. No agent has any right to use his principal's registration number in connection with his own name.

The total number of brands registered by manufacturers was 363, of which 152 brands, equal to 42 per cent of the total, were found by inspectors and analyzed.

*Besides these a considerable number of the remaining purchasers' analyses were doubtless used subsequently as a basis of settlement, but without being reported to this office.

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Agricultural Chemical Works, Los Angeles, Cal.

REGISTRATION No. 8.

Bat Guano
Blood
Bone Meal
Brands A, B, C, F, G, H, K, L, M, N, O
Cottonseed Meal
Fish Guano
Grape and Berry
Gypsum
Lawn and Rose
Muriate of Potash
Nitrate of Soda
Nursery
Potato and Apricot
Prune and Peach
Sulfate of Ammonia
Sulphate of Potash
Summer A
Superphosphate
Tankage
Vegetable
Walnut and Almond
Special mixtures to order of consumers.

American Agricultural Chemical Co., California Works, Los Angeles, Cal.

REGISTRATION No. 1.

Acid Phosphate
Blood.
Bradley's California Vegetable
Bradley's Hay and Grain No. 1
Bradley's Hay and Grain No. 2
Bradley's Lawn
Bradley's Lemon Tree
Bradley's Nursery Stock
Bradley's Orange and Lemon
Bradley's Special Nursery Stock
Bradley's Tree and Vine
Bradley's Nitrate of Soda
Raw Mineral Phosphate Rock
Sulfate of Ammonia
Sulfate of Potash
Tankage
Special brands to order.

Armour Fertilizer Works, Los Angeles, Cal.

REGISTRATION No. 7.

Alfalfa Special
Armour's A, B, and C
Bean Grower
Blood
Bone Blood and Potash
Bone Meal
Cotton Seed Meal
Cropmaker
Deciduous Tree Special
Flower and Fern
Fruit and Vine
Fruit Special
Guano
Lawn and Garden
Lawn Special
Nitrate of Soda
Olive Special
Orange Tree Manure
Orange Tree Special
Sheep Manure
Special 2-12-8
Special 2-17-10
Special 2-20-3
Special 3-20-3
Superphosphate
Sulfate of Ammonia
Sulfate of Potash
Tankage
Vegetable Grower
Walnut Special
Special brands to order of consumers.

Rogers Brown & Co., Los Angeles, Cal.

REGISTRATION No. 85.

Fish Meal
Fish Scrap
Salmon Scrap
Whale Bone Meal
Whale Meat and Blood
Whale Meat and Bone

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California Fertilizer Works, San Francisco, Cal.

REGISTRATION No. 3.

Bone, Blood Meal
Bone, Blood Superphosphate
Special Fall Fertilizer
Special Fruit and Vine
Special High Grade
Special Nitrogen Fertilizer
Special Nursery Stock
Special Orange and Lemon
Special Orange Tree
Special mixtures to order of consumers.

Citrus Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 87.

Blood
Bone Meal
Doty's Fruiting
Doty's Nursery
Doty's Special No. 1
Fish
Guano
Nitrate of Soda
Potash
Sulfate of Ammonia
Superphosphate
Tankage
Special brands to order

Cudahy Packing Co., Los Angeles, Cal.

REGISTRATION No. 79.

A and M Fish Meal
A and M Fish Meal No. 2
Cudahy's Blood
Cudahy's Bone Meal
Cudahy's Fish Formula
Cudahy's Fish Meal No. 2
Cudahy's High Grade Tankage
Cudahy's Low Grade Tankage
Cudahy's Lawn Fertilizer
Cudahy's Lawn Special
Cudahy's Sheep Manure
Cudahy's Tankage Formula
Cudahy's Tankage No. 1
Cudahy's Tankage No. 2

Diamond Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 77.

Barley Straw Baled
Bat Guano
Bean Straw Baled
Blood
Bone
Cotton Seed Meal
Diamond Flower and Fern Food
Diamond Lawn and Garden Fertilizer
Fish Meal
Fish Tankage
Garbage Tankage
Gypsum
Lime
Limestone Rock (ground)
Manure, Goat
Manure, Sheep
Nitrate of Lime
Nitrate of Soda
Phosphate Rock (ground)
Sulfate of Potash
Superphosphate
Tankage
Whale Blood
Whale Bone
Special mixtures to order

Duff's Odorless Fertilizer Co., Glendale, Cal.

REGISTRATION No. 58.

Blood
Bone Meal
Duff's Lawn and Garden No. 1
Duff's Lawn and Garden No. 3
Fish Meal
Nitrate of Soda
Superphosphate
Tankage

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General Fertilizer Association, San Bernardino, Cal.

REGISTRATION No. 42.

G. F. A. Special
G. F. A. Special No. 2
G. F. A. Special No. 3
G. F. A. Special No. 4
G. F. A. Special No. 5
G. F. A. Special No. 6
Orange and Lemon No. 1
Special mixtures to order of consumers

Germain Seed and Plant Co., Los Angeles, Cal.

REGISTRATION No. 76.

Nuvida Blood and Bone
Nuvida Flower and Fern
Nuvida Lawn and Garden Fertilizer
Nuvida Vegetable Fertilizer

Globe Grain and Milling Co., Los Angeles, Cal.

REGISTRATION No. 83.

Samples of Variable Composition

Hauser Packing Co., Los Angeles, Cal.

REGISTRATION No. 33.

High Grade Blood
High Grade Tankage
Low Grade Tankage
Nitrate of Soda
Steam Bone Meal
Sulfate of Potash
Special mixtures to order of consumers

Hawaiian Fertilizer Co., Ltd., San Francisco, Cal.

REGISTRATION No. 19.

Bone Meal
Double Manure Salts
Dry Ground Blood
Fish Guano
Fruit and Vine
Grain A
Grain B
Kainit
Lawn
Lime Nitrogen
Muriate of Potash
Nitrate of Lime
Nitrate of Soda
Nursery
Orange and Lemon
Rape Seed Meal
Sulfate of Ammonia
Sulfate of Potash
Superphosphate
Tankage
Thomas Phosphate Powder
Vegetable
Whale Guano

Thomas Lewis, Sacramento, Cal.

REGISTRATION No. 40.

Tom Lewis Bone Meal
Tom Lewis Fertilizer No. 2
Tom Lewis Star Brand Fertilizer

Los Angeles Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 38.

Three Queens Animal Bone and Potash
Three Queens Emerson's Olive Special
Three Queens Emerson's Fall Special
Three Queens Emerson's Summer Special
Three Queens Emerson's Vegetable
Three Queens Emerson's Walnut Special
Three Queens Fruit Grower
Three Queens Fruitmore
Three Queens Garden and Lawn
Three Queens L. A. Bone Meal
Three Queens Nitrate of Soda
Three Queens Odorless
Three Queens Orangeaid
Three Queens Special Fruit Grower
Three Queens Superphosphate
Three Queens Sulfate of Potash
Three Queens T and B
Three Queens Tankage
Special mixtures to order of consumers

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Leo T. Mizuo, Los Angeles, Cal.

REGISTRATION No. 82.

Bird Guano
Whale Bone

Mountain Copper Co., San Francisco, Cal.

REGISTRATION No. 28.

Mococo Superphosphate 0-17-0
Mococo 0-14-9
Mococo 8-10-2
Mococo 3-10-5
Mococo 4-10-4
Mococo 4.1-10-1.5
Nitrate of Soda
Sulfate of Potash
Special mixtures to order of consumers

Nitrate Agencies Co., Los Angeles, Cal.

REGISTRATION No. 45.

Nitrate of Soda
Potash
Superphosphate

Oakland Meat and Packing Co., Emeryville, Cal.

REGISTRATION No. 24.

"Special"

Pacific Bone, Coal and Fertilizing Co., San Francisco, Cal.

REGISTRATION No. 14.

Arborette No. 1
Arborette No. 2
Blood
Bone Meal
Ceres Brand
Citrona Brand No. 1
Citrona Brand No. 2
Citrona Brand No. 3
Citrona Brand No. 4
Flora Brand
Lime Nitrogen
Lucerna
Lupine Brand
Nitrate of Soda
Pomona Brand
Pomona Brand No. 2
Potash Salts
Steamed Bone and Sulfate of Ammonia
Superphosphate
Tankage
Special Formulas

Pacific Coast Beef and Provision Co., Los Angeles, Cal.

REGISTRATION No. 64.

Bone Meal
Dried Blood
Tankage

Pacific Guano and Fertilizer Co., San Francisco, Cal.

REGISTRATION No. 4.

Brand AJX
Brand CJB
Brand F&V
Brand GG
Brand HOP
Brand IXL
Brand N
Brand OK
Brand PNK
Brand PP
Brand S
Brand TRK
Brand VGR
Brand XLT
Chapman Fall Application
Chapman Fall Application Special
Chapman Spring Application
Superphosphate Cresco
Superphosphate Pacific
Special mixtures to order of consumers

Pacific Reduction Co., Los Angeles, Cal.

REGISTRATION No. 86.

Organic Tankage

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Redlands Fruit Association, Redlands, Cal.

REGISTRATION No. 34.

Blood	Nitrate of Soda
Blood, Packing House	Salmon Scrap
Bone	Sulfate of Potash
Bone, Packing House	Superphosphate
Nitrate of Lime	Tankage

Rialto Orange Co., Rialto, Cal.

REGISTRATION No. 84.

Citrus No. 1	Citrus No. 2

San Antonio Meat Co., Pomona, Cal.

REGISTRATION No. 69.

Magic Lawn and Garden	Tankage

Standard Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 60.

Bone Meal	Standard No. 3
Fish Fertilizer	Standard No. 4
Ground Kelp	Standard No. 5
Standard No. 1	Standard No. 6
Standard No. 2	Standard No. 7

Swift & Co., Chicago, Ill.

REGISTRATION No. 5.

Swift's Diamond "C"	Swift's Diamond "L"
Swift's Diamond "D"	Swift's High Grade Blood
Swift's Diamond "E"	Swift's High Grade Tankage
Swift's Diamond "K"	Swift's Special Bone Meal

Union Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 9.

Blood	Nursery Fertilizer
Bone Meal	Special Fruiting Fertilizer
Fruiting Fertilizer	Sulfate of Potash
Guano	Tankage
Muriate of Potash	Union No. 1
Nitrate of Lime	Union No. 2
Nitrate of Soda	Union No. 3

Union Superphosphate Co., San Francisco, Cal.

REGISTRATION No. 31.

Superphosphate, Cresco	Superphosphate, Pacific

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J. M. Waterman Chemical Co., Los Angeles, Cal.

REGISTRATION No. 75.

Blood
Bone Meal
Gypsum
Grape Pomace
Muriate of Potash
Nitrate of Soda
Sulfate of Potash
Superphosphate
Special mixtures

Western Fertilizer Co., San Francisco, Cal.

REGISTRATION No. 68.

Wizard
Wonder

Western Meat Co., San Francisco, Cal.

REGISTRATION No. 11.

Brands A, B, C, D, E, F, G, H, I, K, L, M, O, R, S
Fair Green
Lemon Special
Nitrate of Soda
Odorless Lawn Dressing
Putting Green
Sulfate of Potash
Superphosphate
Tankage

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Report of Analyses.

Available phosphoric acid is not determined in bone meal, tankage, and Thomas phosphate powder, unless requested. The fineness of these materials is determined, fine and medium bone being separated by a sieve of 50 meshes to the inch; tankage by a 25-mesh sieve; and Thomas phosphate powder by a 100-mesh sieve.

Nitrogen in ammonium salts will, in some cases, be found reported when nitrogen in this form is not guaranteed. In some of such cases this form of nitrogen is produced by conversion of organic nitrogen during process of manufacture, and is not to be considered a deviation from guaranty of materials used. Guanos carry more or less nitrogen in nitrates and ammonium salts, and when any appreciable quantity of guano is used the manufacturer should take into account the fact that some nitrogen will show as nitrates and ammonium salts. The failure to take this into consideration may perhaps account for the appearance of these forms of nitrogen in some samples in which only organic nitrogen was guaranteed.

The percentage of chlorin is given when it exceeds 0.50 per cent. It is a matter of only technical interest whether chlorin present is from muriate of potash, kainit, or from common salt that may be in some of the materials used. If a manufacturer uses sulfate of potash and uses a tankage with it containing a large amount of chlorin, from a practical standpoint he has lowered the grade of his fertilizer just as much as if he had used muriate of potash instead of sulfate of potash. Chlorin from all other sources is as objectionable as from muriate of potash. However, if muriate of potash is found when sulfate is guaranteed, the fact will be published.

The following abbreviations are used in the tables: Bl = blood, Bn = bone, Fs = fish, G = guano, H = hoof, Min. Phos. = mineral phosphate, Super = superphosphates, T = tankage, CSM = cotton seed meal.

Guarantees are entered in italics. Deficiencies greater than allowed by law are entered in bold type.

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Agricultural Chemical Works, Los Angeles, Cal.		
6076	"A"	J. M. Webster, Upland	29.02
6145	"A"	E. A. Moore, Redlands	29.01
6274 *	"A"	A. R. Hoefer, Orange	28.92
6276	"A"	R. R. Sherwood, Lordsburg	29.47
	Guaranteed		*28.00*
6083	"B"	J. M. Webster, Upland	31.15
6144	"B"	E. A. Moore, Redlands	30.57
6340	"B"	E. A. Moore, Redlands	31.87
	Guaranteed		*30.20*
6092	Bat Guano	Henry Fuller, Bryn Mawr	----
	Sold on Station Analysis.		
6056	Blood	W. H. Collins, Covina	59.62
6074	Blood	J. M. Webster, Upland	59.49
6140	Blood	E. A. Moore, Redlands	56.23
6253	Blood	Gowen & Willard, Santa Ana	61.34
6417	Blood	D. F. Bremner, Upland	61.42
	Guaranteed		*59.40*
6139*	Bone Meal	E. A. Moore, Redlands	37.21
6155*	Bone Meal	Union Commission Co., Santa Barbara	37.44
6476*	Bone Meal	R. R. Sherwood, Orange	39.73
	Guaranteed		*37.50*
6287*	Bone Meal	Victoria Ave. Cit. Assn., Riverside	39.38
	Guaranteed		*37.20*
6058	"C"	W. H. Collins, Covina	35.68
6101	"C"	J. M. Webster, Upland	34.66
6143	"C"	E. A. Moore, Redlands	32.69
6218	"C"	G. A. Herdeg, Riverside	31.77
6342	"C"	E. A. Moore, Redlands	34.32
	Guaranteed		*33.40*
6059	"F"	W. H. Collins, Covina	28.14
6266	"F"	Gowen & Willard, Santa Ana	28.73
	Guaranteed		*26.80*
6272	"G"	Gowen & Willard, Santa Ana	27.61
6439	"G"	J. D. McClenny, Pomona	25.28
	Guaranteed		*24.60*
6060	"H"	W. H. Collins, Covina	27.15
6075	"H"	J. M. Webster, Upland	26.14
6103	"H"	J. M. Webster, Upland	25.24
6277	"H"	R. R. Sherwood, Lordsburg	26.17
	Guaranteed		*26.60*
6100	"K"	J. M. Webster, Upland	29.90
6278	"K"	R. R. Sherwood, Lordsburg	28.62
	Guaranteed		*27.80*

*6139—51% fine.
*6155—52% fine.
*6476—47% fine.
*6287—58% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6076	5.88	3.22	9.10	----------	1.42	----	2.42	----------	3.80	3.06	3.06	0.90
6145	4.46	4.14	8.60	----------	0.92	----	2.83	----------	3.75	3.22	3.22	0.55
6274	6.42	2.28	8.70	----------	1.33	----	2.47	----------	3.80	----	3.23	1.45
6276	5.64	3.36	9.00	----------	0.95	----	2.83	----------	3.78	3.22	3.22	0.82
----	*5.00*	*3.00*	*8.00*	*Bn, Super, T*	*2.00*	----	*2.00*	*Bat G, Bl, Bn*	*4.00*	*3.00*	*3.00*	----
6083	5.43	3.02	8.45	----------	1.50	----	3.32	----------	4.82	2.40	2.40	0.70
6144	5.41	3.54	8.95	----------	2.42	----	2.47	----------	4.89	2.20	2.20	----
6340	3.13	4.92	8.05	----------	1.38	----	3.65	----------	5.03	2.44	2.44	0.90
----	*4.00*	*4.00*	*8.00*	*Bn, Super, T*	*2.00*	----	*3.00*	*Bat G, Bl, Bn*	*5.00*	*2.00*	*2.00*	----
6092	----	----	6.45	----------	0.49	1.52	4.91	----------	6.92	----	2.22	----
6056	----	----	----	----------	----	----	13.55	----------	13.55	----	----	----
6074	----	----	----	----------	----	----	13.52	----------	13.52	----	----	----
6140	----	----	----	----------	----	----	12.78	----------	**12.78**	----	----	----
6253	----	----	----	----------	----	----	13.94	----------	13.94	----	----	----
6417	----	----	----	----------	----	----	13.96	----------	13.96	----	----	----
----	----	----	----	----------	----	----	*13.50*	----------	*13.50*	----	----	----
6139	----	----	22.40	----------	----	----	4.06	----------	4.06	----	----	----
6155	----	----	22.70	----------	----	----	4.05	----------	4.05	----	----	----
6476	----	----	24.40	----------	----	----	4.23	----------	4.23	----	----	----
----	----	----	*23.00*	----------	----	----	*4.00*	----------	*4.00*	----	----	----
6287	----	----	24.30	----------	----	----	4.17	----------	4.17	----	----	----
----	----	----	*25.00*	----------	----	----	*3.50*	----------	*3.50*	----	----	----
6058	5.13	2.82	7.95	----------	1.36	----	4.46	----------	5.82	----	2.72	1.07
6101	5.08	3.62	8.70	----------	1.57	----	4.25	----------	5.82	----	1.98	1.52
6143	4.96	3.14	8.10	----------	3.05	----	2.81	----------	5.86	1.92	1.92	0.82
6218	4.88	2.82	7.70	----------	1.99	----	3.34	----------	**5.33**	2.22	2.22	0.87
6342	**2.93**	4.82	7.75	----------	2.20	----	3.54	----------	**5.74**	2.72	2.72	0.85
----	*4.00*	*4.00*	*8.00*	*Bn, Super, T*	*3.00*	----	*3.00*	*Bat G, Bl, Bn*	*6.00*	*2.00*	*2.00*	----
6059	6.20	2.60	8.80	----------	0.82	----	2.20	----------	3.02	4.18	4.18	0.60
6266	6.35	2.50	8.85	----------	0.77	----	2.40	----------	3.17	4.11	4.11	0.75
----	*6.00*	*2.00*	*8.00*	*Bn, Super, T*	*1.00*	----	*2.00*	*Bat G, Bl, Bn*	*3.00*	*4.00*	*4.00*	----
6272	7.51	4.54	12.05	----------	0.84	----	2.19	----------	3.03	2.44	2.44	----
6439	4.50	6.40	10.90	----------	0.93	----	1.97	----------	2.90	2.11	2.11	0.55
----	*6.00*	*4.00*	*10.00*	*Bn, Super, T*	*1.00*	----	*2.00*	*Bat G, Bl, Bn*	*3.00*	*2.00*	*2.00*	----
6060	6.74	4.26	11.00	----------	0.80	----	1.96	----------	2.76	3.23	3.23	0.70
6075	6.55	4.10	10.65	----------	0.98	----	1.90	----------	2.88	2.72	2.72	0.75
6103	5.95	3.50	9.45	----------	----	----	2.58	----------	**2.58**	2.95	2.95	0.95
6277	6.12	3.68	9.80	----------	----	----	2.76	----------	2.76	2.88	2.88	0.80
----	*6.00*	*4.00*	*10.00*	*Bn, Super, T*	*1.00*	----	*2.00*	*Bat G, Bl, Bn*	*3.00*	*3.00*	*3.00*	----
6100	5.31	4.54	9.85	----------	1.56	----	2.72	----------	4.28	2.31	2.31	----
6278	6.20	4.10	10.30	----------	0.70	----	3.13	----------	3.83	1.98	1.98	0.95
----	*6.00*	*4.00*	*10.00*	*Bn, Super, T*	*2.00*	----	*2.00*	*Bat G, Bl, Bn*	*4.00*	*2.00*	*2.00*	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Agricultural Chemical Works— Continued.		
6078	"L"	J. M. Webster, Upland	29.86
6275	"L"	A. R. Hoefer, Orange	32.15
	Guaranteed		*30.60*
6142	Lawn	E. A. Moore, Redlands	25.68
6219	Lawn	G. A. Herdeg, Riverside	25.93
6265	Lawn	Gowen & Willard, Santa Ana	27.10
	Guaranteed		*24.50*
6279	"M"	R. R. Sherwood, Lordsburg	27.08
	Guaranteed		*27.30*
6061	"N"	W. H. Collins, Covina	38.29
6079	"N"	J. M. Webster, Upland	37.85
	Guaranteed		*38.00*
6420	Nitrate and Bone	Geo. T. Vance, Jr., Upland	45.36
	Guaranteed		*46.40*
6341	"O"	E. A. Moore, Redlands	29.98
	Guaranteed		*26.00*
6138	Special	E. A. Moore, Redlands	59.68
	Guaranteed		*61.20*
6343	Special	E. A. Moore, Redlands	40.39
	Guaranteed		*40.60*
6419	Special	W. J. Stowe et al., Los Angeles	27.58
6455	Special	Erasmus Wilson, San Gabriel	29.42
6477	Special	R. R. Sherwood, Orange	28.80
	Guaranteed		*28.00*
6440	Special	J. D. McClenny, Pomona	27.90
6479	Special	R. R. Sherwood, Orange	25.75
	Guaranteed		*25.60*
6478	Special	R. R. Sherwood, Orange	31.24
	Guaranteed		*32.20*
6146	Summer B	E. A. Moore, Redlands	31.94
	Guaranteed		*31.60*
6148	Summer C	E. A. Moore, Redlands	38.49
	Guaranteed		*38.00*
6273*	Tankage	A. R. Hoefer, Orange	31.74
	Guaranteed		*31.92*
6281*	Tankage	J. D. McClenny, Pomona	30.17
	Guaranteed		*29.40*
6057	Tankage Fertilizer	W. H. Collins, Covina	35.34
6141	Tankage Fertilizer	E. A. Moore, Redlands	36.14
6280	Tankage Fertilizer	J. D. McClenny, Pomona	35.80
6438	Tankage Fertilizer	J. D. McClenny, Pomona	36.43
	Guaranteed		*35.20*

*6273—71% fine.
*6281—78% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6078	6.56	3.74	10.30	--------	1.00	----	1.86	--------	2.86	4.79	4.79	0.67
6275	6.05	4.00	10.05	--------	1.12	----	2.00	--------	3.12	5.56	5.56	0.75
----	*5.00*	*5.00*	*10.00*	*Bn, Super, T*	*1.00*	----	*2.00*	*Bat G, Bl, Bn*	*3.00*	*5.00*	*5.00*	----
6142	4.83	5.42	10.25	--------	----	----	2.59	--------	2.59	----	2.79	2.70
6219	4.15	6.86	11.00	--------	----	----	2.57	--------	2.57	2.62	2.62	----
6265	6.09	4.96	11.05	--------	----	----	2.89	--------	2.89	----	2.51	1.77
----	*5.00*	*5.00*	*10.00*	*Super, T*	----	----	*2.50*	*Bat G, Bl, Bn*	*2.50*	----	*2.50*	----
6279	8.00	4.20	12.20	--------	----	----	2.42	--------	2.42	2.97	2.97	0.70
----	*7.00*	*5.00*	*12.00*	*Bn, Super, T*	----	----	*2.50*	*Bat G, Bl, Bn*	*2.50*	*3.00*	*3.00*	----
6061	6.97	2.78	9.75	--------	1.06	----	3.91	--------	4.97	----	4.85	1.25
6079	6.74	2.56	9.30	--------	1.34	----	3.64	--------	4.98	4.95	4.95	0.90
----	*5 00*	*5.00*	*10.00*	*Bn, Super, T*	*2.00*	----	*3.00*	*Bat G, Bl, Bn*	*5.00*	*5.00*	*5.00*	----
6420	----	----	1.20	--------	13.94	----	0.18	--------	14.12	----	----	----
----	----	----	*.50*	*Bn*	*14.50*	----	----	--------	*14.50*	----	----	----
6341	4.06	4.34	8.40	--------	1.06	----	3.34	--------	4.40	2.50	2.50	0.75
----	*5.00*	*3.00*	*8.00*	*Bn. Super, T*	*2.00*	----	*2.00*	*Bat G, Bl, Bn*	*4.00*	*2.00*	*2.00*	----
6138	----	----	----	--------	----	3.98	10.67	--------	14.65	----	----	----
----	----	----	----	--------	----	*4.00*	*11.00*	*Bl*	*15.00*	----	----	----
6343	----	----	9.25	--------	1.83	----	6.24	--------	8.07	----	----	----
----	----	----	*10.00*	*Bn, Fs, G, T*	*2.00*	----	*6.00*	*Bl, Bn, Fs, G, T*	*8.00*	----	----	----
6419	----	----	10.20	--------	1.80	----	3.01	--------	4.81	----	----	----
6455	----	----	10.05	--------	1.00	----	4.09	--------	5.09	----	----	----
6477	----	----	10.00	--------	1.12	----	3.86	--------	4.98	----	----	----
----	----	----	*10.00*	*Bn, Super, T*	*2.00*	----	*3.00*	*Bat G, Bl, Bn, Fs*	*5.00*	----	----	----
6440	----	----	12.60	--------	1.50	----	2.80	--------	4.30	----	----	----
6479	----	----	11.75	--------	1.08	----	2.79	--------	3.87	----	----	----
----	----	----	*12.00*	*Bn, Super, T*	*2.00*	----	*2.00*	*Bat G, Bl, Bn, Fs*	*4.00*	----	----	----
6478	----	----	10.05	--------	1.54	----	4.11	--------	5.65	----	----	----
----	----	----	*10.00*	*Bn, Super, T*	*2.00*	----	*4.00*	*Bat G, Bl, Bn, Fs*	*6.00*	----	----	----
6146	4.43	3.32	7.75	--------	----	----	2.34	--------	2.34	7.57	7.57	0.75
----	*5.00*	*3.00*	*8.00*	*Bn, Super, T*	----	----	*2.00*	*Bat G, Bl, Bn*	*2.00*	*8.00*	*8.00*	----
6148	4.07	3.88	7.95	--------	1.73	----	2.18	--------	3.91	8.32	8.32	0.70
----	*5.00*	*3.00*	*8.00*	*Bn, Super, T*	*2.00*	----	*2.00*	*Bat G, Bl, Bn*	*4.00*	*8.00*	*8.00*	----
6273	----	----	13.60	--------	----	----	5.29	--------	5.29	----	----	----
----	----	----	*13.50*	--------	----	----	*5.35*	--------	*5.35*	----	----	----
6281	----	----	12.20	--------	----	----	5.15	--------	5.15	----	----	----
----	----	----	*12.00*	--------	----	----	*5.00*	--------	*5.00*	----	----	----
6057	----	----	8.00	--------	----	2.85	4.91	--------	7.76	----	----	----
6141	----	----	7.80	--------	----	2.88	5.11	--------	7.99	----	----	----
6280	----	----	8.15	--------	----	2.75	5.07	--------	7.82	----	----	----
6438	----	----	8.65	--------	2.33	1.23	4.52	--------	8.08	----	----	----
----	----	----	*8.00*	--------	----	*4.00*	*4.00*	--------	*8.00*	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	American Agricultural Chemical Co., Los Angeles, Cal.		
6099	Bradley's California Vegetable	G. L. Winterbotham, Riverside	27.25
6220	Bradley's California Vegetable	F. E. Dudderar, Covina	29.50
6243	Bradley's California Vegetable	M. R. Williams, Monrovia	29.30
	Guaranteed		*27.46*
6168	Bradley's Grain No. 2	Fresno Fuel Co., Fresno	23.79
6241	Bradley's Grain No. 2	M. R. Williams, Monrovia	21.44
	Guaranteed		*20.90*
6130	Bradley's Lawn	E. M. Cope, Commercial Co., Redlands	27.31
6167	Bradley's Lawn	Fresno Fuel Co., Fresno	28.28
6217	Bradley's Lawn	Morris & Snow Seed Co., Los Angeles	27.15
6221	Bradley's Lawn	F. E. Dudderar, Covina	27.55
6242	Bradley's Lawn	M. R. Williams, Monrovia	27.26
6456	Bradley's Lawn	A. W. Blake, Pasadena	26.13
6481	Bradley's Lawn	Campbell Seed Store, Pasadena	26.62
6527	Bradley's Lawn	L. M. Jacobs Co., Pasadena	25.56
	Guaranteed		*26.12*
6251	Bradley's Lemon Tree	Pacific Wood & Coal Co., San Diego	27.65
	Guaranteed		*26.12*
6102	Bradley's Nursery Stock	G. L. Winterbotham, Riverside	26.51
6134	Bradley's Nursery Stock	E. C. Robinson, Pomona	26.08
6166	Bradley's Nursery Stock	Fresno Fuel Co., Fresno	28.77
6214	Bradley's Nursery Stock	W. H. Grant, Porterville	29.72
6222	Bradley's Nursery Stock	F. E. Dudderar, Covina	27.35
6282	Bradley's Nursery Stock	F. E. Dudderar, Covina	27.81
6344	Bradley's Nursery Stock	R. S. Thompson, Highland	28.38
6393	Bradley's Nursery Stock	R. H. Hille, San Fernando	27.88
6403	Bradley's Nursery Stock	W. S. Fenton, Ontario	26.33
	Guaranteed		*26.12*
6129	Bradley's Orange and Lemon	E. M. Cope Commercial Co., Redlands	28.17
	Guaranteed		*26.74*
	Armour Fertilizer Works, Los Angeles, Cal.		
6227	Armour's A	Factory at Porterville	32.13
	Guaranteed		*28.80*
6228	Armour's B	Factory at Porterville	43.18
	Guaranteed		*37.80*
6229	Armour's C	Factory at Porterville	70.40
	Guaranteed		*68.60*
6055	Blood	Miss A. R. Brown, Covina	61.60
	Guaranteed		*62.30*
6069	Blood	N. H. Garrison, Ontario	62.13
	Guaranteed		*62.35*
6121	Blood	E. F. Wilson, Upland	60.68
	Guaranteed		*60.85*

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6099	8.29	0.76	9.05	----------	1.83	0.77	0.64	----------	3.24	4.05	4.05	----
6220	8.50	0.70	9.20	----------	2.06	0.75	0.83	----------	3.64	4.37	4.37	----
6243	8.12	1.38	9.50	----------	2.01	0.58	0.92	----------	3.51	4.30	4.30	----
----	*8.00*	*1.00*	*9.00*	*Bn, Super*	*1.90*	*0.60*	*0.80*	*Bat G, Bl, Bn, T*	*3.30*	*4.00*	*4.00*	----
6168	8.38	0.32	9.70	----------	1.65	0.35	0.99	----------	2.99	2.25	2.25	----
6241	8.52	0.88	9.40	----------	1.13	0.49	0.86	----------	2.48	2.09	2.09	----
----	*8.00*	*1.00*	*9.00*	*Bn, Super*	*1.26*	*0.31*	*0.90*	*Bat G, Bl, Bn, T*	*2.47*	*2.00*	*2.00*	----
6130	8.87	1.28	10.15	----------	2.25	0.74	1.15	----------	4.14	1.89	1.89	----
6167	9.02	0.98	10.00	----------	2.63	0.71	0.98	----------	4.32	2.24	2.24	----
6217	9.15	1.20	10.35	----------	2.26	0.76	1.06	----------	4.08	1.86	1.86	0.52
6221	9.48	1.32	10.80	----------	2.35	0.77	1.05	----------	4.17	1.72	1.72	----
6242	9.34	1.36	10.70	----------	2.31	0.77	1.09	----------	4.17	1.60	1.60	----
6456	8.62	1.28	9.90	----------	2.28	0.95	0.91	----------	4.14	1.53	1.53	----
6481	8.93	1.22	10.15	----------	2.67	0.96	0.62	----------	4.25	1.63	1.63	----
6527	8.66	1.54	10.20	----------	2.29	0.90	0.76	----------	3.95	1.49	1.49	----
----	*9.00*	*1.00*	*10.00*	*Bn, Super,*	*2.35*	*0.75*	*1.00*	*Bat G, Bl, Bn, T*	*4.10*	*1.50*	*1.50*	----
6251	9.30	1.40	10.70	----------	2.12	0.78	1.30	----------	4.20	1.64	1.64	----
----	*9.00*	*1.00*	*10.00*	*Bn, Super,*	*2.35*	*0.75*	*1.00*	*Bat G, Bl, Bn, T*	*4.10*	*1.50*	*1.50*	----
6102	9.14	1.06	10.20	----------	2.39	0.79	0.95	----------	4.13	1.58	1.58	----
6134	8.93	1.12	10.05	----------	3.15	----	0.88	----------	4.03	1.63	1.63	----
6166	9.25	1.00	10.25	----------	2.63	0.74	0.92	----------	4.29	2.45	2.45	----
6214	9.59	1.36	10.95	----------	2.69	0.75	1.16	----------	4.60	1.99	1.99	----
6222	9.79	0.86	10.65	----------	2.56	0.70	0.97	----------	4.23	1.63	1.63	----
6282	9.08	1.32	10.40	----------	2.46	0.84	1.05	----------	4.35	1.74	1.74	----
6344	9.58	1.62	11.20	----------	2.48	0.78	1.12	----------	4.38	1.58	1.58	----
6393	8.85	1.60	10.45	----------	2.49	0.67	1.19	----------	4.35	1.68	1.68	0.52
6403	8.87	1.48	10.35	----------	2.22	0.92	0.94	----------	4.08	1.51	1.51	----
----	*9.00*	*1.00*	*10.00*	*Bn, Super*	*2.35*	*0.75*	*1.00*	*Bat, G, Bl, Bn, T*	*4.10*	*1.50*	*1.50*	----
6129	7.20	1.90	9.10	----------	2.14	0.66	0.90	----------	3.70	3.62	3.62	----
----	*8.00*	*1.00*	*9.00*	*Bn, Super*	*2.20*	*0.70*	*0.80*	*Bat G, Bl, Bn, T*	*3.70*	*3.00*	*3.00*	----
6227	14.08	5.22	19.30	----------	1.54	----	2.34	----------	3.88	----	----	----
----	----	----	*15.00*	*Bn, Super*	*1.50*	----	*2.50*	*Bl, Bn*	*4.00*	----	----	----
6228	11.95	2.80	14.75	----------	----	----	----	----------	----	14.95	14.95	0.85
----	----	----	*12.00*	*Super*	----	----	----	----------	----	*13.50*	*13.50*	----
6229	----	----	----	----------	2.41	----	5.62	----------	8.03	19.54	19.54	1.25
----	----	----	----	----------	*3.00*	----	*5.00*	*Bl*	*8.00*	*19.00*	*19.00*	----
6055	----	----	----	----------	----	----	14.00	----------	14.00	----	----	----
----	----	----	----	----------	----	----	*14.16*	----------	*14.16*	----	----	----
6069	----	----	----	----------	----	----	14.12	----------	14.12	----	----	----
----	----	----	----	----------	----	----	*14.17*	----------	*14.17*	----	----	----
6121	----	----	----	----------	----	----	13.79	----------	13.79	----	----	----
----	----	----	----	----------	----	----	*13.83*	----------	*13.83*	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Armour Fertilizer Works—Continued.		
6136	Blood	R. T. Murrell, Pomona	59.14
6198	Blood	E. F. Schrei, Lindsay	60.85
6336	Blood	W. T. Henderson, Riverside	63.58
6351	Blood	I. W. Freeman, Anaheim	60.15
6538	Blood	W. H. McCune, Jr., Monrovia	58.70
	Guaranteed		*61.60*
6238	Blood	A. M. Seeley, Covina	61.56
	Guaranteed		*60.24*
6307	Blood	A. P. Griffith Estate, Azusa	59.44
6308	Blood	A. P. Griffith Estate, Azusa	59.22
6309	Blood	A. P. Griffith Estate, Azusa	59.22
6335	Blood	W. T. Henderson, Riverside	60.32
6380	Blood	R. E. Fairchild, Redlands	60.19
6413	Blood	R. T. Murrell, Pomona	60.28
6510	Blood	Mrs. L. S. Poage, Azusa	60.10
	Guaranteed		*60.28*
6313	Blood	Redlands Fruit Assn., Redlands	62.39
	Guaranteed		*62.52*
6379	Blood	R. E. Fairchild, Redlands	63.14
	Guaranteed		*62.26*
6500	Blood	Azusa Foot-Hill Cit. Co., Azusa	57.90
6501	Blood	Azusa Foot-Hill Cit. Co., Azusa	58.61
6502	Blood	Azusa Foot-Hill Cit. Co., Azusa	58.96
6503	Blood	Azusa Foot-Hill Cit. Co., Azusa	57.51
6504	Blood	Azusa Foot-Hill Cit. Co., Azusa	58.78
6505	Blood	Azusa Foot-Hill Cit. Co., Azusa	58.56
6512	Blood	Azusa Foot-Hill Cit. Co., Azusa	58.78
6513	Blood	Azusa Foot-Hill Cit. Co., Azusa	58.37
6520	Blood	W. H. Lindley, Ontario	58.08
	Guaranteed		*57.20*
6306	Blood	A. M. Seeley, Covina	----
	Sold on Station Analysis.		
6119	Bone, Blood and Potash	E. F. Wilson, Upland	39.24
6240	Bone, Blood and Potash	A. M. Seeley, Covina	4014
	Guaranteed		*37.80*
6204	Bone, Blood and Potash	E. F. Schrei, Lindsay	41.65
	Guaranteed		*38.30*
6201*	Bone Meal	E. A. Zumbro, Riverside	38.97
	Guaranteed		*34.65*
6202*	Bone Meal	E. F. Schrei, Lindsay	34.22
	Guaranteed		*31.20*
6210*	Bone Meal	Chas. Fesler, Covina	36.48
6268*	Bone Meal	S. S. Scofield, Azusa	34.44
6269*	Bone Meal	Mrs. James Fleming, San Bernardino	36.25
	Guaranteed		*33.15*
6212*	Bone Meal	Azusa Foot-Hill Cit. Co., Azusa	35.44
6213*	Bone Meal	Azusa Foot-Hill Cit. Co., Azusa	35.83
6254*	Bone Meal	Azusa Foot-Hill Cit. Co., Azusa	36.43

*6201—51% fine.
*6202—75% fine.
*6210—65% fine.
*6268—65% fine.
*6269—75% fine.
*6212—63% fine.
*6213—71% fine.
*6254—73% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6136	----	----	----	---------	----	----	13.44	---------	13.44	----	----	----
6198	----	----	----	---------	----	----	13.83	---------	13.83	----	----	----
6326	----	----	----	---------	----	----	14.45	---------	14.45	----	----	----
6351	----	----	----	---------	----	----	13.67	---------	13.67	----	----	----
6538	----	----	----	---------	----	----	13.34	---------	13.34	----	----	----
----	----	----	----	---------	----	----	*14.00*	---------	*14.00*	----	----	----
6238	----	----	----	---------	----	----	13.99	---------	13.99	----	----	----
----	----	----	----	---------	----	----	*13.69*	---------	*13.69*	----	----	----
6307	----	----	----	---------	----	----	13.51	---------	13.51	----	----	----
6308	----	----	----	---------	----	----	13.46	---------	13.46	----	----	----
6309	----	----	----	---------	----	----	13.46	---------	13.46	----	----	----
6335	----	----	----	---------	----	----	13.71	---------	13.71	----	----	----
6380	----	----	----	---------	----	----	13.68	---------	13.68	----	----	----
6413	----	----	----	---------	----	----	13.70	---------	13.70	----	----	----
6510	----	----	----	---------	----	----	13.66	---------	13.66	----	----	----
----	----	----	----	---------	----	----	*13.70*	---------	*13.70*	----	----	----
6313	----	----	----	---------	----	----	14.18	---------	14.18	----	----	----
----	----	----	----	---------	----	----	*14.21*	---------	*14.21*	----	----	----
6379	----	----	----	---------	----	----	14.35	---------	14.35	----	----	----
----	----	----	----	---------	----	----	*14.15*	---------	*14.15*	----	----	----
6500	----	----	----	---------	----	----	13.16	---------	13.16	----	----	----
6501	----	----	----	---------	----	----	13.32	---------	13.32	----	----	----
6502	----	----	----	---------	----	----	13.40	---------	13.40	----	----	----
6503	----	----	----	---------	----	----	13.07	---------	13.07	----	----	----
6504	----	----	----	---------	----	----	13.36	---------	13.36	----	----	----
6505	----	----	----	---------	----	----	13.31	---------	13.31	----	----	----
6512	----	----	----	---------	----	----	13.36	---------	13.36	----	----	----
6513	----	----	----	---------	----	----	13.38	---------	13.38	----	----	----
6520	----	----	----	---------	----	----	13.20	---------	13.20	----	----	----
----	----	----	----	---------	----	----	*13.00*	---------	*13.00*	----	----	----
6306	----	----	----	---------	----	----	13.60	---------	13.60	----	----	----
6119	8.18	1.92	10.10	---------	0.98	0.95	2.09	---------	4.02	----	7.60	1.55
6240	8.26	2.14	10.40	---------	1.10	1.02	2.18	---------	4.30	----	7.42	1.05
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.00*	*1.00*	*2.00*	*Bl, Bn, G, T, C S Meal*	*4.00*	*7.00*	*7.00*	----
6204	7.34	2.76	10.10	---------	1.62	----	3.09	---------	4.71	7.20	7.20	0.87
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.50*	----	*2.50*	*Bl, Bn, G, T*	*4.00*	*7.00*	*7.00*	----
6201	----	----	23.70	---------	----	----	4.20	---------	4.20	----	----	----
----	----	----	*21.00*	---------	----	----	*3.75*	---------	*3.75*	----	----	----
6202	----	----	29.90	---------	----	----	1.74	---------	1.74	----	----	----
----	----	----	*28.23*	---------	----	----	*1.38*	---------	*1.38*	----	----	----
6210	----	----	27.00	---------	----	----	2.90	---------	2.90	----	----	----
6268	----	----	25.20	---------	----	----	2.80	---------	2.80	----	----	----
6269	----	----	26.70	---------	----	----	2.91	---------	2.91	----	----	----
----	----	----	*24.00*	---------	----	----	*2.75*	---------	*2.75*	----	----	----
6212	----	----	26.50	---------	----	----	2.76	---------	2.76	----	----	----
6213	----	----	26.70	---------	----	----	2.81	---------	2.81	----	----	----
6254	----	----	26.90	---------	----	----	2.91	---------	2.91	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Armour Fertilizer Works— Continued.		
6255*	Bone Meal	Azusa Foot-Hill Cit. Co., Azusa	36.28
6256*	Bone Meal	Azusa Foot-Hill Cit. Co., Azusa	35.98
6257*	Bone Meal	Azusa Foot-Hill Cit. Co., Azusa	35.98
6258*	Bone Meal	Azusa Foot-Hill Cit. Co., Azusa	35.92
6259*	Bone Meal	Azusa Foot-Hill Cit. Co., Azusa	35.65
	Guaranteed		*32.10*
6249*	Bone Flour	H. P. Greene, San Diego	33.32
	Guaranteed		*31.80*
6349*	Bone Meal	I. W. Freeman, Anaheim	34.53
	Guaranteed		*30.30*
6250*	Bone Meal	H. P. Greene, San Diego	34.71
	Guaranteed		*34.71*
6430*	Bone Meal	E. M. Hudson, Los Angeles	33.72
	Guaranteed		*36.60*
6348*	Bone Meal	I. W. Freeman, Anaheim	35.23
	Guaranteed		*36.00*
6459*	Bone Meal	John Blake, Pasadena	35.71
	Guaranteed		*38.20*
6483*	Bone Meal	H. M. Bradley, Riverside	33.15
	Guaranteed		*34.80*
6120	Cropmaker	E. F. Wilson, Upland	30.94
6330	Cropmaker	J. C. Boyd, Rialto	30.83
6338	Cropmaker	W. T. Henderson, Riverside	31.49
6352	Cropmaker	I. W. Freeman, Anaheim	29.51
6381	Cropmaker	R. E. Fairchild, Redlands	31.71
6392	Cropmaker	W. H. Wyckoff, Redlands	29.08
6465	Cropmaker	Tuolumne S. & W. P. Co., Sonora	29.37
	Guaranteed		*27.80*
6232	Cropmaker Special	Factory at Porterville	33.19
	Guaranteed		*28.30*
6247	Cropmaker Special	H. P. Green, San Diego	29.45
	Guaranteed		*26.80*
6357	Cropmaker Special	I. W. Freeman, Anaheim	28.08
	Guaranteed		*29.80*
6466	Cropmaker Special	Mrs. James Fleming, San Bernardino	29.42
6537	Cropmaker Special	W. H. McCune, Jr., Monrovia	28.17
	Guaranteed		*28.30*
6428	Cotton Seed Meal	E. M. Hudson, Los Angeles	28.31
	Guaranteed		*33.92*
6284	Cyanamid	A. M. Seeley, Covina	59.71
	Guaranteed		*59.20*
6451*	Fish Meal	E. M. Hudson, Los Angeles	41.40
	Guaranteed		*40.95*
6452*	Fish Meal	E. M. Hudson, Los Angeles	40.87
	Guaranteed		*35.70*
6453*	Fish Meal	E. M. Hudson, Los Angeles	41.71
	Guaranteed		*43.46*

*6250—55% fine. By mistake of manufacturer, since corrected. This was originally guaranteed nitrogen 2.50; phosphoric acid 22.00.
*6255—73% fine.
*6256—76% fine.
*6257—74% fine.
*6258—76% fine.
*6259—74% fine.
*6249—95% fine.
*6349—71% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6255	----	----	27.20	---------	----	----	2.81	---------	2.81	----	----	----
6256	----	----	27.80	---------	----	----	2.61	---------	2.61	----	----	----
6257	----	----	27.10	---------	----	----	2.76	---------	2.76	----	----	----
6258	----	----	26.70	---------	----	----	2.83	---------	2.83	----	----	----
6259	----	----	27.80	---------	----	----	2.53	---------	2.53	----	----	----
----	----	----	*24.00*	---------	----	----	*2.50*	---------	*2.50*	----	----	----
6249	----	----	26.10	---------	----	----	2.34	---------	2.34	----	----	----
----	----	----	*26.00*	---------	----	----	*2.00*	---------	*2.00*	----	----	----
6349	----	----	28.10	---------	----	----	2.20	---------	2.20	----	----	----
----	----	----	*22.00*	---------	----	----	*2.50*	---------	*2.50*	----	----	----
6250	----	----	32.50	---------	----	----	1.30	---------	1.30	----	----	----
----	----	----	*32.50*	---------	----	----	*1.30*	---------	*1.30*	----	----	----
6430	----	----	23.70	---------	----	----	4.14	---------	4.14	----	----	----
----	----	----	*22.00*	---------	----	----	*4.00*	---------	*4.00*	----	----	----
6348	----	----	27.10	---------	----	----	2.58	---------	2.58	----	----	----
----	----	----	*26.00*	---------	----	----	*3.00*	---------	*3.00*	----	----	----
6459	----	----	28.20	---------	----	----	2.46	---------	2.46	----	----	----
----	----	----	*28.40*	---------	----	----	*3.01*	---------	*3.01*	----	----	----
6483	----	----	23.30	---------	----	----	4.09	---------	4.09	----	----	----
----	----	----	*20.00*	---------	----	----	*4.00*	---------	*4.00*	----	----	----
6120	8.94	1.46	10.40	---------	1.03	1.17	2.10	---------	4.30	----	2.86	1.08
6330	7.50	3.10	10.60	---------	1.15	1.05	2.14	---------	4.34	----	2.63	1.00
6338	7.71	2.94	10.65	---------	0.92	1.19	2.34	---------	4.45	----	2.66	1.15
6352	7.05	3.80	10.85	---------	0.96	1.04	2.10	---------	4.10	2.26	2.26	0.85
6381	8.18	2.82	11.00	---------	1.05	1.19	2.20	---------	4.44	----	2.70	1.05
6392	7.22	3.58	10.80	---------	1.02	1.06	2.01	---------	4.09	----	2.13	1.10
6465	7.34	3.06	10.40	---------	1.05	0.85	2.23	---------	4.13	----	2.28	1.17
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.00*	*1.00*	*2.00*	*Bl, Bn, G, T, C S Meal*	*4.00*	----	*2.00*	----
6232	8.00	3.00	11.00	---------	1.54	----	2.89	---------	4.43	3.11	3.11	0.80
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.50*	----	*2.50*	*Bl, Bn, G, T*	*4.00*	*2.00*	*2.00*	----
6247	8.66	2.24	10.90	---------	2.84	----	1.08	---------	3.92	3.01	3.01	0.95
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*3.00*	----	*1.00*	*Bl, Bn, G, T*	*4.00*	*2.00*	*2.00*	----
6357	----	----	9.85	---------	----	----	3.85	---------	3.85	----	1.52	1.10
----	----	----	*10.00*	*Bn*	----	----	*4.00*	*Bl, Bn, G, T*	*4.00*	*2.00*	*2.00*	----
6466	7.18	3.42	10.60	---------	1.60	----	2.39	---------	3.99	----	2.36	1.75
6537	7.08	3.42	10.50	---------	1.79	----	2.05	---------	3.84	----	2.19	1.15
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.50*	----	*2.50*	*Bl, Bn, G, T*	*4.00*	*2.00*	*2.00*	----
6428	----	----	2.55	---------	----	----	5.60	---------	5.60	1.50	1.50	----
----	----	----	*2.80*	---------	----	----	*6.80*	---------	*6.80*	*1.70*	*1.70*	----
6284	----	----	----	---------	----	----	----	---------	18.66	----	----	----
----	----	----	----	---------	----	----	----	---------	*18.50*	----	----	----
6451	----	----	7.30	---------	----	----	8.64	---------	8.64	----	----	----
----	----	----	*6.00*	---------	----	----	*8.75*	---------	*8.75*	----	----	----
6452	----	----	6.25	---------	----	----	8.69	---------	8.69	----	----	----
----	----	----	*4.80*	---------	----	----	*7.70*	---------	*7.70*	----	----	----
6453	----	----	7.70	---------	----	----	8.60	---------	8.60	----	----	----
----	----	----	*6.89*	---------	----	----	*9.20*	---------	*9.20*	----	----	----

*6430—51% fine.
*6348—72% fine.
*6459—76% fine.
*6483—48% fine.

*6451—67% fine.
*6452—63% fine.
*6453—74% fine.

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Armour Fertilizer Works— Continued.		
6442	Flower and Fern Food	E. M. Hudson, Los Angeles	35.22
	Guaranteed		*34.00*
6231	Fruit and Vine	Factory at Porterville	37.39
	Guaranteed		*34.60*
6206	Lawn and Garden	E. F. Schrei, Lindsay	31.28
6226	Lawn and Garden	Factory at Porterville	35.10
	Guaranteed		*27.80*
6244	Lawn Special	H. P. Greene, San Diego	26.47
	Guaranteed		*25.40*
6360	Lawn Special	I. W. Freeman, Anaheim	27.39
6429	Lawn Special	E. M. Hudson, Los Angeles	25.82
6457	Lawn Special	John Blake, Pasadena	26.11
6473	Lawn Special	I. W. Freeman, Anaheim	23.00
	Guaranteed		*26.40*
6245	Special Lawn Special	H. P. Greene, San Diego	25.66
	Guaranteed		*24.90*
6118	Nitrate of Soda	E. F. Wilson, Upland	48.06
6137	Nitrate of Soda	R. T. Murrell, Pomona	48.32
6203	Nitrate of Soda	E. F. Schrei, Lindsay	48.51
6285	Nitrate of Soda	A. M. Seeley, Covina	50.27
6329	Nitrate of Soda	J. C. Boyd, Rialto	48.86
6339	Nitrate of Soda	W. T. Henderson, Riverside	48.51
	Guaranteed		*48.00*
6054	Orange Tree Manure	A. B. Hill, Pomona	28.70
6207	Orange Tree Manure	E. F. Schrei, Lindsay	32.98
6233	Orange Tree Manure	Factory at Porterville	32.58
6382	Orange Tree Manure	R. E. Fairchild, Redlands	30.67
6474	Orange Tree Manure	I. W. Freeman, Anaheim	31.02
	Guaranteed		*28.10*
6124	Orange Tree Special	E. F. Wilson, Upland	26.88
6458	Orange Tree Special	John Blake, Pasadena	28.88
	Guaranteed		*26.10*
6358	Special Orange Tree Special	Anaheim Cit. Fruit Assn., Anaheim	27.72
	Guaranteed		*27.60*
6359	Special Orange Tree Manure	Garden Grove Lmb. Co., Garden Grove	29.25
	Guaranteed		*28.10*
6383	Special Orange Tree Manure	R. E. Fairchild, Redlands	31.00
	Guaranteed		*29.60*
6098	Special	C. L. Nye, Riverside	38.77
	Guaranteed		*36.60*

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6442	7.15	3.20	10.35	--------	2.47	----	2.78	--------	5.25	3.16	3.16	0.97
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*2.00*	----	*3.00*	*Bl, Bn, G, T*	*5.00*	*3.00*	*3.00*	----
6231	5.82	2.58	8.40	--------	0.95	----	1.16	--------	2.11	10.96	10.96	0.85
----	*6.00*	*2.00*	*8.00*	*Bn, G, Super*	*1.00*	----	*1.00*	*Bl, Bn, G, T, C S Meal*	*2.00*	*10.00*	*10.00*	----
6206	4.24	2.36	6.60	--------	1.65	----	2.78	--------	4.43	4.19	4.19	0.70
6226	4.45	2.20	6.65	--------	1.36	----	3.12	--------	4.48	5.83	5.83	0.90
----	*4.00*	*1.00*	*5.00*	*Bn, G, Super*	*1.50*	----	*2.50*	*Bl, Bn, G, T*	*4.00*	*4.00*	*4.00*	----
6244	3.91	1.64	5.55	--------	2.05	----	2.27	--------	4.32	2.69	2.69	0.87
----	*4.00*	*1.00*	*5.00*	*Bn, G, Super*	*2.00*	----	*2.50*	*Bl, Bn, G, T*	*4.50*	*2.00*	*2.00*	----
6360	2.20	3.10	5.30	--------	1.20	----	3.50	--------	4.70	----	2.04	1.45
6429	3.05	2.30	5.35	--------	1.08	----	3.33	--------	4.41	----	1.78	1.30
6457	3.24	2.16	5.40	--------	1.27	----	3.14	--------	4.41	----	2.00	1.30
6473	3.01	1.94	4.95	--------	1.21	----	2.58	--------	3.79	----	1.92	1.02
----	*4.00*	*1.00*	*5.00*	*Bn, G, Super*	*1.00*	----	*3.50*	*Bl, Bn, G, T, C S Meal*	*4.50*	*2.00*	*2.00*	----
6245	4.26	1.14	5.40	--------	2.23	----	2.04	--------	4.27	----	2.55	1.05
----	*4.00*	*1.00*	*5.00*	*Bn, G, Super*	*2.50*	----	*2.00*	*Bl, Bn, G, T, C S Meal*	*4.50*	*2.00*	*2.00*	----
6118	----	----	----	--------	15.02	----	----	--------	15.02	----	----	----
6137	----	----	----	--------	15.10	----	----	--------	15.10	----	----	----
6203	----	----	----	--------	15.16	----	----	--------	15.16	----	----	----
6285	----	----	----	--------	15.71	----	----	--------	15.71	----	----	----
6329	----	----	----	--------	15.27	----	----	--------	15.27	----	----	----
6339	----	----	----	--------	15.16	----	----	--------	15.16	----	----	----
----	----	----	----	--------	*15.00*	----	----	--------	*15.00*	----	----	----
6054	8.51	1.24	9.75	--------	1.00	0.50	1.53	--------	3.03	----	4.35	1.65
6207	7.85	2.70	10.55	--------	1.63	----	1.92	--------	3.55	5.10	5.10	0.90
6233	8.61	2.74	11.35	--------	1.55	----	1.81	--------	3.36	4.90	4.90	----
6382	8.24	2.16	10.40	--------	1.17	0.55	1.62	--------	3.34	4.50	4.50	0.97
6474	7.11	3.64	10.75	--------	1.49	----	1.47	--------	2.96	5.20	5.20	0.80
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.00*	*0.50*	*1.50*	*Bl, Bn, G, T, C S Meal*	*3.00*	*4.00*	*4.00*	----
6124	7.96	2.34	10.30	--------	1.15	0.59	1.29	--------	3.03	3.31	3.31	0.80
6458	7.47	3.78	11.25	--------	0.71	0.55	1.82	--------	3.08	3.54	3.54	0.82
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.00*	*0.50*	*1.50*	*Bl, Bn, G, T*	*3.00*	*3.00*	*3.00*	----
6358	----	----	10.00	--------	----	----	3.09	--------	3.09	2.87	2.87	0.80
----	----	----	*10.00*	*Bn,*	----	----	*3.00*	*Bl, Bn, T*	*3.00*	*3.00*	*3.00*	----
6359	7.44	2.36	9.80	--------	1.54	----	1.69	--------	3.23	4.20	4.20	0.55
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.50*	----	*1.50*	*Bl, Bn, G, T*	*3.00*	*4.00*	*4.00*	----
6383	8.49	2.36	10.85	--------	1.10	0.52	1.64	--------	3.26	4.58	4.58	0.90
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	----	----	----	--------	*3.00*	*4.00*	*4.00*	----
6098	6.03	5.32	11.35	--------	0.76	----	2.11	--------	2.87	8.63	8.63	0.72
----	*10.00*	----	----	*Bn, G, Super*	*1.00*	----	*2.00*	*Bl, Bn, G, T*	*3.00*	*8.00*	*8.00*	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Armour Fertilizer Works—Continued.		
6126	Special	E. F. Wilson, Upland	38.67
	Guaranteed		*36.60*
6122	Special	E. F. Wilson, Upland	33.53
6236	Special	A. M. Seeley, Covina	36.37
	Guaranteed		*32.40*
6125	Special	E. F. Wilson, Upland	33.70
	Guaranteed		*31.50*
6199	Special	E. F. Schrei, Lindsay	36.46
	Guaranteed		*34.70*
6205	Special	E. F. Schrei, Lindsay	38.94
	Guaranteed		*34.10*
6208	Special, Powers	Factory at Porterville	43.82
	Guaranteed		*40.10*
6225	Special	Factory at Porterville	45.08
	Guaranteed		*44.30*
6246	Special	H. P. Greene, San Diego	39.58
	Guaranteed		*38.80*
6377	Special	D. P. Stone, Redlands	33.59
	Guaranteed		*33.00*
6378	Special	D. P. Stone, Redlands	42.43
	Guaranteed		*41.00*
6398	Special	Mrs. M. Gray, Ontario	33.01
	Guaranteed		*32.20*
6450	Special	E. M. Hudson, Los Angeles	21.80
	Guaranteed		*21.20*
6472	Special Vegetable	I. W. Freeman, Anaheim	26.23
	Guaranteed		*26.40*
6237	Special 6-8-1	A. M. Seeley, Covina	37.58
6471	Special 6-8-1	I. W. Freeman, Anaheim	38.14
6486	Special 6-8-1	L. Drendel, Azusa	34.93
6487	Special 6-8-1	Chas. Menefee, Covina	34.75
6499	Special 6-8-1	Mrs. S. F. McDonald, Glendora	34.56
	Guaranteed		*34.40*
6109*	Tankage	E. F. Wilson, Upland	42.47
6350*	Tankage	I. W. Freeman, Anaheim	42.78
	Guaranteed		*45.35*
6200*	Tankage	H. M. Bradley, Riverside	30.65
6211*	Tankage	W. S. Hathaway, Riverside	31.40
6239*	Tankage	A. M. Seeley, Covina	31.98
	Guaranteed		*31.85*

*6109—62% fine.
*6350—61% fine.
*6200—68% fine.
*6211—71% fine.
*6239—70% fine. Some hoof.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6126	----	----	20.10	--------	----	----	3.28	--------	3.28	3.40	3.40	0.60
----	----	----	*20.00*	*Bn*	----	----	*3.00*	*Bl, Bn, T*	*3.00*	*3.00*	*3.00*	----
6122	----	----	19.80	--------	----	----	2.25	--------	2.25	3.13	3.13	----
6236	----	----	21.40	--------	----	----	2.54	--------	2.54	3.22	3.22	----
----	----	----	*20.00*	*Bn, Super*	----	----	*2.00*	*Bl, Bn, T*	*2.00*	*3.00*	*3.00*	----
6125	7.85	2.30	10.15	--------	1.04	1.61	2.52	--------	5.17	----	2.75	1.65
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.00*	*1.50*	*2.50*	*Bl, Bn, G, T, C S Meal*	*5.00*	*2.00*	*2.00*	----
6199	7.61	4.94	12.55	--------	0.60	----	1.53	--------	2.13	8.41	8.41	0.85
----	*8.00*	*4.00*	*12.00*	*Bn, G, Super*	*0.50*	----	*1.50*	*Bn, G*	*2.00*	*8.00*	*8.00*	----
6205	7.87	2.68	10.55	--------	1.52	----	1.92	--------	3.44	----	8.26	1.35
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.50*	----	*1.50*	*Bl, Bn, G, T, C S Meal*	*3.00*	*7.00*	*7.00*	----
6208	7.44	2.66	10.10	--------	1.43	----	1.88	--------	3.31	----	11.13	1.22
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.50*	----	*1.50*	*Bl, Bn, G, T*	*3.00*	*10.00*	*10.00*	----
6225	8.01	2.24	10.25	--------	1.69	----	2.14	--------	3.83	----	10.73	1.32
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*1.50*	----	*2.50*	*Bl, Bn, G, T*	*4.00*	*10.00*	*10.00*	----
6246	7.99	3.16	11.15	--------	2.92	----	0.98	--------	3.90	8.04	8.04	0.90
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*3.00*	----	*1.00*	*Bl, Bn, G, T*	*4.00*	*8.00*	*8.00*	----
6377	----	----	13.80	--------	1.41	----	2.47	--------	3.88	----	3.14	1.17
----	----	----	*13.00*	*Bn, G, Super*	*1.50*	----	*2.50*	*Bl, Bn, G, T*	*4.00*	*3.00*	*3.00*	----
6378	----	----	13.70	--------	1.53	----	2.42	--------	3.95	----	7.52	1.15
----	----	----	*13.00*	*Bn, G, Super*	*1.50*	----	*2.50*	*Bl, Bn, G, T*	*4.00*	*7.00*	*7.00*	----
6398	----	----	8.55	--------	----	----	4.96	--------	4.96	----	2.24	1.47
----	----	----	*8.00*	*Bn, Super*	----	----	*5.00*	*Bl, Bn, T*	*5.00*	*2.00*	*2.00*	----
6450	5.67	2.98	8.65	--------	0.66	----	1.89	--------	2.55	----	1.98	2.00
----	*6.00*	*2.00*	*8.00*	*Bn, Super*	*0.50*	----	*2.00*	*Bl, Bn, T*	*2.50*	*2.00*	*2.00*	----
6472	----	----	5.55	--------	1.36	----	3.03	--------	4.39	----	2.08	1.35
----	----	----	*5.00*	*Bn, G, Super*	*1.00*	----	*3.50*	*Bl, Bn, G, T, C S Meal*	*4.50*	*2.00*	*2.00*	----
6237	----	----	9.20	--------	----	----	6.29	--------	6.29	1.44	1.44	0.62
6471	----	----	9.20	--------	----	----	6.39	--------	6.39	1.51	1.51	0.67
6486	----	----	8.70	--------	----	----	5.91	--------	5.91	----	1.14	1.70
6487	----	----	8.40	--------	----	----	5.93	--------	5.93	----	0.95	1.70
6499	----	----	8.35	--------	----	----	6.04	--------	6.04	----	0.84	1.20
----	----	----	*8.00*	*Bn, G, C S Meal*	----	----	*6.00*	*Bl, Bn, G, T, C S Meal*	*6.00*	*1.00*	*1.00*	----
6109	----	----	6.05	--------	----	----	9.08	--------	9.08	----	----	----
6350	----	----	6.15	--------	----	----	9.16	--------	9.16	----	----	----
----	----	----	*5.50*	--------	----	----	*9.88*	--------	*9.88*	----	----	----
6200	----	----	13.60	--------	----	----	5.03	--------	5.03	----	----	----
6211	----	----	14.25	--------	----	----	5.10	--------	5.10	----	----	----
6239	----	----	14.85	--------	----	----	5.14	--------	5.14	----	----	----
----	----	----	*14.00*	--------	----	----	*5.25*	--------	*5.25*	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Armour Fertilizer Works—Continued.		
6292*	Tankage	Glendora Land Co., Glendora	38.97
	Guaranteed		*32.35*
6337*	Tankage	W. T. Henderson, Riverside	36.88
	Guaranteed		*38.15*
6327*	Tankage	E. F. Wilson, Upland	40.69
	Guaranteed		*40.67*
6388*	Tankage	R. T. Murrell, Pomona	30.33
	Guaranteed		*29.40*
6389*	Tankage	R. T. Murrell, Pomona	39.54
	Guaranteed		*37.72*
6397*	Tankage	H. G. Koster, Upland	39.91
	Guaranteed		*41.15*
6425*	Tankage	W. B. Cullen, Glendora	44.49
6426*	Tankage	C. W. Richardson, Glendora	45.00
	Guaranteed		*43.44*
6427*	Tankage	E. M. Hudson, Los Angeles	21.13
	Guaranteed		*19.84*
6433*	Tankage	J. G. Gaylord, Ontario	42.67
	Guaranteed		*43.33*
6441*	Tankage	E. M. Hudson, Los Angeles	52.16
	Guaranteed		*51.95*
6482*	Tankage	J. W. Mays et al., Riverside	35.92
	Guaranteed		*38.89*
6506*	Tankage	John McInerney, San Dimas	39.52
	Guaranteed		*39.20*
6541*	Tankage	W. H. McCune, Jr., Monrovia	43.37
	Guaranteed		*43.33*
6304*	Tankage	J. W. Corwin et al., Highland	----
6305*	Tankage	A. M. Seeley, Covina	----
	Sold on Station Analysis.		
6068	2-17-5	W. A. Lucas, Cucamonga	38.15
	Guaranteed		*38.70*
	Rogers Brown & Co., Los Angeles, Cal.		
6515*	Tankage	Orange Heights Fruit Assn., Corona	41.24
	Guaranteed		*35.92*
6421*	Whale Meat and Bone	W. C. Nickerson, Redlands	39.20
	Guaranteed		*39.42*
6435*	Whale Meat and Bone	Rialto Orange-Lemon Assn., Rialto	44.15
	Guaranteed		*46.66*

*6292—73% fine. Some hoof.
*6337—65% fine.
*6327—81% fine.
*6388—69% fine.
*6389—73% fine.
*6397—67% fine.
*6425—72% fine.
*6426—71% fine.
*6427—58% fine.
*6433—69% fine.
*6441—75% fine.
*6482—77% fine.
*6506—76% fine.
*6541—66% fine.
*6304—69% fine.
*6305—67% fine.
*6515—67% fine.
*6421—58% fine.
*6435—60% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6292	----	----	7.55	----	----	----	8.02	----	8.02	----	----	----
----	----	----	*6.86*	----	----	----	*6.56*	----	*6.56*	----	----	----
6337	----	----	6.55	----	----	----	7.69	----	7.69	----	----	----
----	----	----	*6.50*	----	----	----	*8.00*	----	*8.00*	----	----	----
6327	----	----	15.05	----	----	----	7.18	----	7.18	----	----	----
----	----	----	*13.70*	----	----	----	*7.40*	----	*7.40*	----	----	----
6388	----	----	14.65	----	----	----	4.78	----	4.78	----	----	----
----	----	----	*15.00*	----	----	----	*4.50*	----	*4.50*	----	----	----
6389	----	----	7.65	----	----	----	8.14	----	8.14	----	----	----
----	----	----	*7.02*	----	----	----	*7.81*	----	*7.81*	----	----	----
6397	----	----	11.60	----	----	----	7.57	----	7.57	----	----	----
----	----	----	*11.38*	----	----	----	*7.90*	----	*7.90*	----	----	----
6425	----	----	8.35	----	----	----	9.20	----	9.20	----	----	----
6426	----	----	8.60	----	----	----	9.28	----	9.28	----	----	----
----	----	----	*7.93*	----	----	----	*9.02*	----	*9.02*	----	----	----
6427	----	----	4.50	----	----	----	4.28	----	4.28	----	----	----
----	----	----	*4.34*	----	----	----	*4.00*	----	*4.00*	----	----	----
6433	----	----	8.40	----	----	----	8.76	----	8.76	----	----	----
----	----	----	*7.90*	----	----	----	*9.00*	----	*9.00*	----	----	----
6441	----	----	----	----	----	----	12.42	----	12.42	----	----	----
----	----	----	----	----	----	----	*12.37*	----	*12.37*	----	----	----
6482	----	----	11.95	----	----	----	6.56	----	6.56	----	----	----
----	----	----	*11.57*	----	----	----	*7.33*	----	*7.33*	----	----	----
6506	----	----	8.10	----	----	----	8.06	----	8.06	----	----	----
----	----	----	*8.00*	----	----	----	*8.00*	----	*8.00*	----	----	----
6541	----	----	8.25	----	----	----	9.07	----	9.07	----	----	----
----	----	----	*7.90*	----	----	----	*9.00*	----	*9.00*	----	----	----
6304	----	----	8.70	----	----	----	8.46	----	8.46	----	----	----
6305	----	----	14.95	----	----	----	5.23	----	5.23	----	----	----
6068	----	----	16.80	----	----	----	2.55	----	2.55	6.16	6.16	0.95
----	----	----	*17.00*	*Bn, G, Super*	----	----	*2.00*	*Bl, Bn, G, T*	*2.00*	*5.00*	*5.00*	----
6515	----	----	9.60	----	----	----	8.22	----	8.22	----	----	----
----	----	----	*11.90*	----	----	----	6.57	----	6.57	----	----	----
6421	----	----	12.80	----	----	----	7.20	----	7.20	----	----	----
----	----	----	*13.00*	----	----	----	7.22	----	7.22	----	----	----
6435	----	----	7.75	----	----	----	9.22	----	9.22	----	----	----
----	----	----	*5.33*	----	----	----	*10.22*	----	*10.22*	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	California Fertilizer Works, San Francisco, Cal.		
6047	Special	A. C. Denman & Sons, Redlands	29.43
	Guaranteed		*30.70*
6178	Special Nursery Stock	A. C. Dungan, Exeter	28.15
	Guaranteed		*27.80*
6325*	Tankage	Stewart Cit. Assn., Upland	41.41
6355*	Tankage	Stewart Cit. Assn., Upland	41.76
	Guaranteed		*43.12*
6354*	Tankage	Stewart Cit. Assn., Upland	40.46
	Guaranteed		*39.61*
	Cudahy Packing Co., Los Angeles, Cal.		
6404	Blood	I. W. Haskell et al., Azusa	59.97
	Guaranteed		*60.50*
6542	Blood	J. H. Stewart, Redlands	----
	Sold on Station Analysis.		
6248*	Bone Meal Steamed	Geo. Wright, Azusa	----
	Sold on Station Analysis.		
6235	Cudahy's Commercial Fertilizer	Jerome Reynolds, Covina	----
	Sold on Station Analysis.		
6444*	Cudahy's Mixed Fertilizer	R. M. Douglas, Covina	32.24
	Guaranteed		*36.40*
6402	Cudahy's Special Lawn	Valley Supply Co., Glendale	30.12
	Guaranteed		*32.00*
6407*	Tankage No. 1	Mrs. E. P. Hubbard, Azusa	39.69
6446*	Tankage No. 1	H. H. Church, Covina	39.94
6511*	Tankage No. 1	Mrs. O. F. Wright, Azusa	40.14
	Guaranteed		*37.80*
6408*	Tankage	S. S. Scofield et al., Azusa	40.89
6529*	Tankage No. 2	B. L. King, Covina	45.28
6530*	Tankage No. 2	B. L. King, Covina	40.78
	Guaranteed		*40.60*
6405*	Tankage	W. M. Warren, Covina	----
6406*	Tankage	I. W. Haskell et al., Azusa	----
	Sold on Station Analysis.		

*6444—No statement of derivation. In violation of California Fertilizer Act.
*6325—85% fine.
*6355—86% fine.
*6354—84% fine.
*6248—71% fine.
*6407—78% fine.
*6446—78% fine.
*6511—78% fine.
*6408—76% fine.
*6529—76% fine.
*6530—76% fine.
*6405—79% fine.
*6406—78% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6047	----	----	11.60	---------	1.61	0.48	2.31	---------	4.40	1.80	1.30	0.65
----	----	----	*12.00*	*Bn*	*2.00*		*2.50*	*Bl, Bn*	*4.50*	*1.50*	*1.50*	----
6178	4.61	5.14	9.85	---------	1.94	0.58	1.48	---------	4.00	2.50	2.50	0.97
----	*6.50*	*3.50*	*10.00*	*Bn, Super*	*2.00*		*2.00*	*Bl, Bn*	*4.00*	*2.00*	*2.00*	----
6325	----	----	9.00	---------	----	----	8.36	---------	8.36	----	----	----
6355	----	----	9.25	---------	----	----	8.40	---------	8.40	----	----	----
----	----	----	*10.00*	---------	----	----	*8.60*	---------	*8.60*	----	----	----
6354	----	----	8.90	---------	----	----	8.15	---------	8.15	----	----	----
----	----	----	*9.80*	---------	----	----	7.88	---------	7.88	----	----	----
6404	----	----	----	---------	----	----	13.63	---------	13.63	----	----	----
----	----	----	----	---------	----	----	*13.75*	---------	*13.75*	----	----	----
6542	----	----	----	---------	----	----	13.51	---------	13.51	----	----	----
6248	----	----	20.70	---------	----	----	3.04	---------	3.04	----	----	----
6235	----	----	15.50	---------	----	----	2.31	---------	2.31	----	3.55	1.67
6444	----	----	9.50	---------	----	----	4.77	---------	4.77	----	1.83	2.07
----	----	----	*8.00*	---------	----	----	*6.00*	---------	*6.00*	----	*2.00*	----
6402	----	----	11.80	---------	----	----	4.75	---------	4.75	----	0.43	2.35
----	----	----	*8.00*	---------	----	----	*4.00*	---------	*4.00*	----	*4.00*	----
6407	----	----	9.00	---------	----	----	7.95	---------	7.95	----	----	----
6446	----	----	7.55	---------	----	----	8.25	---------	8.25	----	----	----
6511	----	----	7.00	---------	----	----	8.39	---------	8.39	----	----	----
----	----	----	*6.00*	---------	----	----	*8.00*	---------	*8.00*	----	----	----
6408	----	----	9.40	---------	----	----	8.17	---------	8.17	----	----	----
6529	----	----	6.30	---------	----	----	9.73	---------	9.73	----	----	----
6530	----	----	8.75	---------	----	----	8.25	---------	8.25	----	----	----
----	----	----	*10.00*	---------	----	----	*8.00*	---------	*8.00*	----	----	----
6405	----	----	6.90	---------	----	----	9.28	---------	9.28	----	----	----
6406	----	----	5.75	---------	----	----	9.75	---------	9.75	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Diamond Fertilizer Co., Los Angeles, Cal.		
6051*	Garbage Tankage	W. H. Young, Duarte	----
	Guaranteed		----
6117*	Garbage Tankage	G. A. Hansen Fruit Co., Upland	----
	Guaranteed		----
6131*	Garbage Tankage	Henry Fuller, Bryn Mawr	----
6147*	Garbage Tankage	Henry Fuller, Redlands	----
6286*	Garbage Tankage	Oak Knoll Co., Pasadena	----
6449*	Garbage Tankage	Robert Baird, Porterville	----
	Guaranteed		----
6052*	Garbage Tankage	A. B. Hill, Pomona	----
6053*	Garbage Tankage	A. B. Hill, Pomona	----
6067*	Garbage Tankage	L. A. Smith, Cucamonga	----
	Sold on Station Analysis.		
	Duff's Odorless Fertilizer Co., Glendale, Cal.		
6395	No. 1	Manufacturer's Warehouse	16.25
	Guaranteed		*19.10*
6396	No. 3	Manufacturer's Warehouse	----
	Guaranteed		----
6514	No. 3	R. P. Kleinhaus, Malden, Wash	----
	Guaranteed		----
	General Fertilizer Association, San Bernardino, Cal.		
6288	Bat Guano	H. D. Derwin, Upland	39.35
	Guaranteed		*44.73*
6400	Bat Guano	H. D. Derwin, Upland	----
	Sold on Station Analysis.		
6531*	Bone Meal	J. E. Schermerhorn, Highgrove	38.44
	Guaranteed		*36.15*
6493*	Fish Meal	J. A. Hall, Cucamonga	46.11
	Guaranteed		*48.65*
6491*	Garbage Tankage	D. R. Kilbourne, Cucamonga	----
6492*	Garbage Tankage	W. E. Morse, Alta Loma	----
	Guaranteed		----
6071	G. F. A. No. 2	Factory at Ontario	28.49
	Guaranteed		*28.80*
6111	G. F. A. Special No. 2	J. H. Reynolds, Redlands	28.05
	Guaranteed		*27.80*
6321	G. F. A. Special No. 2	J. H. Reynolds, Redlands	24.03
	Guaranteed		*29.80*
6460	G. F. A. Special No. 2	F. F. Oster, Los Angeles	23.13
	Guaranteed		*29.20*

*6051—29% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6117—29% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6131—27% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6147—28% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6286—23% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6449—28% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6052—28% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6053—27% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6067—27% fine. In absence of market quotations no prices are given on Garbage Tankage.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6051	----	----	2.80	--------	----	----	3.10	--------	3.10	----	1.25	----
----	----	----	*3.15*	--------	----	----	*3.10*	--------	*3.10*	----	*1.22*	----
6117	----	----	3.10	--------	----	----	3.17	--------	3.17	----	1.07	1.20
----	----	----	*4.00*	--------	----	----	*3.30*	--------	*3.30*	----	*1.25*	----
6131	----	----	2.90	--------	----	----	3.28	--------	3.28	----	1.22	1.57
6147	----	----	2.85	--------	----	----	3.37	--------	3.37	----	1.02	1.25
6286	----	----	2.60	--------	----	----	3.23	--------	3.23	----	1.32	0.72
6449	----	----	2.65	--------	----	----	3.51	--------	3.51	----	1.52	1.32
----	----	----	*3.00*	--------	----	----	*3.00*	--------	*3.00*	----	*1.00*	----
6052	----	----	3.05	--------	----	----	3.06	--------	3.06	----	1.46	----
6053	----	----	3.05	--------	----	----	3.10	--------	3.10	----	1.23	----
6067	----	----	3.30	--------	----	----	*3.34*	--------	*3.34*	----	*1.32*	----
6395	4.52	1.08	5.60	--------	1.12	0.72	0.93	--------	2.77	----	0.71	----
----	----	----	*5.00*	*Bn, G, Super*	----	----	----	*Bn, G*	*3.00*	----	*1.00*	----
6396	----	----	2.90	--------	----	0.78	1.21	--------	1.99	----	1.17	0.57
----	----	----	*1.00*	*G*	----	----	*1.00*	*G*	*1.00*	----	*1.00*	----
6514	----	----	2.70	--------	----	1.10	0.86	--------	1.96	----	1.31	0.57
----	----	----	*1.00*	*Bn, G*	----	----	----	*Bn, G*	*1.50*	----	*1.00*	----
6288	----	----	4.40	--------	2.17	1.66	5.05	--------	8.88	----	0.96	----
----	----	----	*4.48*	--------	----	----	----	--------	*9.00*	----	*1.45*	----
6400	----	----	4.40	--------	0.39	1.37	8.20	--------	9.96	----	0.90	----
6531	----	----	26.10	--------	----	----	3.56	--------	3.56	----	----	----
----	----	----	*25.00*	--------	----	----	*3.25*	--------	*3.25*	----	----	----
6493	----	----	6.35	--------	----	----	9.92	--------	9.92	----	----	----
----	----	----	*6.50*	--------	----	----	*10.50*	--------	*10.50*	----	----	----
6491	----	----	2.35	--------	----	----	3.07	--------	3.07	----	1.23	1.35
6492	----	----	2.20	--------	----	----	2.96	--------	2.96	----	1.24	1.20
----	----	----	*2.00*	--------	----	----	*3.00*	--------	*3.00*	----	*1.00*	----
6071	6.03	3.82	9.85	--------	1.79	----	2.18	--------	3.97	----	2.37	1.25
----	*8.00*	*2.00*	*10.00*	--------	*1.50*	----	2.62	*Bl, Bn, G*	*4.12*	----	*2.00*	----
6111	5.14	7.16	12.30	--------	2.30	----	1.62	--------	3.92	----	1.41	1.25
----	*5.00*	*5.00*	*10.00*	*Bn, G*	*2.00*	----	*2.00*	*Bl, Bn, G*	*4.00*	----	*2.00*	----
6321	2.93	6.32	9.25	--------	1.70	----	1.62	--------	3.32	----	1.73	----
----	*5.00*	*5.00*	*10.00*	*Bn. G.*	*2.00*	----	*2.00*	*Bl, Bn, G*	*4.00*	----	*3.00*	----
6460	4.02	4.48	8.50	--------	1.69	0.42	1.46	--------	3.57	1.30	1.30	0.77
----	*5.00*	*3.00*	*8.00*	*Bn, G*	*2.00*	----	3.00	*Bl, Bn, G*	*5.00*	----	*1.50*	----

*6531—51% fine.
*6493—68% fine.
*6491—33% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6492—36% fine. In absence of market quotations no prices are given on Garbage Tankage.

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	General Fertilizer Association— Continued.		
6073	G. F. A. No. 3	Factory at Ontario	26.79
6191	G. F. A. No. 3	G. F. Fish, Ontario	28.16
	Guaranteed		*25.33*
6072	G. F. A. No. 5	Factory at Ontario	34.62
	Guaranteed		*34.30*
6533	G. F. A. No. 5	Factory at Ontario	33.08
	Guaranteed		*32.50*
6322	G. F. A. No. 5 Special	J. H. Reynolds, Redlands	30.78
	Guaranteed		*32.00*
6110	Orange and Lemon No. 1	J. H. Reynolds, Redlands	34.32
6320	Orange and Lemon No. 1	J. H. Reynolds, Redlands	29.17
	Guaranteed		*34.30*
6070	Special Lawn	Factory at Ontario	33.73
	Guaranteed		*33.94*
6532	Special Mixed	L. R. Lee, Ontario	33.90
	Guaranteed		*35.55*
	Germain Seed and Plant Co., Los Angeles, Cal.		
6362*	Nuvida Lawn and Garden	Manufacturer's Warehouse	27.02
6401*	Nuvida Lawn and Garden	Valley Supply Co., Glendale	28.55
	Guaranteed		*23.80*
	Globe Grain and Milling Co., Los Angeles, Cal.		
6361*	Garbage Tankage	Manufacturer's Warehouse	----
	Guaranteed		----
	Hauser Packing Company, Los Angeles, Cal.		
6463	Blood	Geo. W. Fuhr, Azusa	59.31
	Guaranteed		*62.35*
6489	Blood	K. Lundeen, Los Angeles	54.87
	Guaranteed		*52.80*
6544	Blood	E. N. Nahmens, Redlands	62.88
	Guaranteed		*62.22*
6080*	Bone Meal	Stewart Cit. Assn., Upland	35.36
6081*	Bone Meal	Stewart Cit. Assn., Upland	35.53
6082*	Bone Meal	Stewart Cit. Assn., Upland	35.65
6132*	Bone Meal	Stewart Cit. Assn., Upland	32.66
6150*	Bone Meal	Stewart Cit. Assn., Upland	34.44
6151*	Bone Meal	Stewart Cit. Assn., Upland	34.34
	Guaranteed		*32.55*

*6362—Nitrogen given as nitric is guaranteed from cyanamid.
*6401—Nitrogen given as nitric is guaranteed from cyanamid.
*6361—31% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6080—71% fine.
*6081—69% fine.
*6082—67% fine.
*6132—65% fine.
*6150—71% fine.
*6151—73% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6073	**4.01**	**3.94**	7.95	---------	1.29	----	1.02	---------	**2.31**	----	5.61	0.72
6191	----	----	10.75	---------	----	----	1.83	---------	1.83	----	5.40	----
----	*6.00*	*4.00*	*10.00*	*Bn, G*	*0.60*	----	*1.05*	*Bl, Bn, G*	*1.65*	----	*5.00*	----
6072	----	----	11.20	---------	1.66	----	3.56	---------	5.22	----	2.14	1.25
----	----	----	*12.00*	*Bn, G, T*	*1.50*	----	*3.50*	*Bl, Bn, G*	*5.00*	----	*2.00*	----
6533	----	----	10.55	---------	1.86	----	3.26	---------	5.12	----	1.97	0.57
----	----	----	*10.00*	*Bn, G, T*	*1.50*	----	*3.50*	*Bl, Bn, G*	*5.00*	----	*2.00*	----
6322	**3.57**	8.08	11.65	---------	2.56	----	2.00	---------	**4.56**	----	1.85	0.60
----	*6.00*	*4.00*	*10.00*	*Bn, G*	*2.00*	----	*3.00*	*Bl, Bn, G*	*5.00*	----	*2.00*	----
6110	**6.44**	**3.46**	9.90	---------	1.67	----	2.51	---------	4.18	4.76	4.76	1.00
6320	**1.94**	**6.86**	8.80	---------	2.00	----	2.05	---------	4.05	3.12	**3.12**	0.60
----	*5.00*	*5.00*	*10.00*	*Bn, G, Super*	*1.50*	----	*2.50*	---------	*4.00*	*5.00*	*5.00*	----
6070	----	----	6.85	---------	2.55	----	4.62	---------	7.17	----	----	----
----	----	----	*7.00*	*Bn, G*	*2.60*	----	*4.60*	*Bl, Bn, G*	*7.20*	----	----	----
6532	----	----	5.35	---------	----	----	7.18	---------	**7.18**	----	0.41	----
----	----	----	*5.36*	*Bn, G*	----	----	*7.57*	*Bl, Bn, G*	*7.57*	----	*0.75*	----
6362	**8.17**	**2.08**	10.25	---------	----	----	----	---------	4.81	----	----	----
6401	**8.91**	**2.14**	11.05	---------	----	----	----	---------	4.43	----	----	----
----	*7.00*	*3.00*	*10.00*	---------	*2.00*	----	*2.00*	*Bl*	*4.00*	----	----	----
6361	----	----	2.75	---------	----	----	3.58	---------	3.58	----	1.21	1.52
----	----	----	*3.00*	---------	----	----	*3.00*	---------	*3.00*	----	*1.00*	----
6463	----	----	----	---------	----	----	13.48	---------	**13.48**	----	----	----
----	----	----	----	---------	----	----	*14.17*	---------	*14.17*	----	----	----
6489	----	----	----	---------	----	----	12.47	---------	12.47	----	----	----
----	----	----	----	---------	----	----	*12.00*	---------	*12.00*	----	----	----
6544	----	----	----	---------	----	----	14.29	---------	14.29	----	----	----
----	----	----	----	---------	----	----	*14.14*	---------	*14.14*	----	----	----
6080	----	----	23.00	---------	----	----	3.49	---------	3.49	----	----	----
6081	----	----	23.00	---------	----	----	3.53	---------	3.53	----	----	----
6082	----	----	22.20	---------	----	----	3.73	---------	3.73	----	----	----
6132	----	----	20.10	---------	----	----	3.47	---------	3.47	----	----	----
6150	----	----	21.00	---------	----	----	3.70	---------	3.70	----	----	----
6151	----	----	21.40	---------	----	----	3.59	---------	3.59	----	----	----
----	----	----	*21.00*	---------	----	----	*3.25*	---------	*3.25*	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Hauser Packing Co.— Continued.		
6209*	Bone Meal	Michael Rebhan, Covina	37.00
	Guaranteed		*34.95*
6293*	Bone Meal	W. M. Baird, Duarte	22.57
	Guaranteed		*21.60*
6525*	Garbage Tankage	Curtis Ranch Co., Bloomington	----
6526*	Garbage Tankage	Curtis Ranch Co., Bloomington	----
	Guaranteed		----
6536	Special	W. B. Glidden, Hollywood	30.35
	Guaranteed		*29.80*
6048*	Tankage	J. C. Wright, Azusa	42.18
6373*	Tankage	J. C. Wright, Azusa	40.58
6418*	Tankage	D. F. Bremner, Upland	39.94
6423*	Tankage	A. B. Cowgill, Redlands	39.67
6434*	Tankage	H. C. Meek, Upland	39.03
6534*	Tankage	C. W. Rhodes, Pasadena	39.66
6543*	Tankage	E. N. Nahmens, Redlands	39.49
	Guaranteed		*39.20*
6475*	Tankage	D. W. Divine, Highland	40.68
	Guaranteed		*39.06*
6370*	Tankage, Big Gun	E. D. Berry, Los Angeles	44.64
6371*	Tankage, Big Gun	H. Damerel et al., Covina	45.12
6372*	Tankage, Big Gun	Mrs. J. H. Simpson, Covina	44.79
6384*	Tankage, Big Gun	E. E. Ebersale, Lordsburg	45.35
6447*	Tankage	J. H. Simpson, Covina	44.51
6495*	Tankage	G. N. Hamilton, Claremont	43.38
	Guaranteed		*44.80*
6090*	Tankage	Orange Hts. Ft. Grws. Assn., Corona	----
6091*	Tankage	Corona Cit. Assn., Corona	----
	Sold on Station Analysis.		
	Hawaiian Fertilizer Co., Ltd., San Francisco, Cal.		
6185*	Bone Meal	Lindsay Hay & Grain Co., Lindsay	33.68
	Guaranteed		*32.70*
6184*	Fish Guano	Lindsay Hay & Grain Co., Lindsay	42.41
	Guaranteed		*38.85*
6181	Fruit and Vine A	Lindsay Hay & Grain Co., Lindsay	41.75
	Guaranteed		*38.30*
6187	Fruit and Vine B	Lindsay Hay & Grain Co., Lindsay	34.95
	Guaranteed		*29.30*
6179	Nitrate of Soda	Lindsay Hay & Grain Co., Lindsay	49.86
	Guaranteed		*48.00*
6180	Nursery	Lindsay Hay & Grain Co., Lindsay	35.82
	Guaranteed		*31.50*

*6209—73% fine.
*6293—66% fine.
*6525—39% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6526—47% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6048—67% fine.
*6373—73% fine.
*6418—56% fine.
*6423—60% fine.
*6434—68% fine.
*6534—71% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6209	----	----	23.10	--------	----	----	3.86	--------	3.86	----	----	----
----	----	----	*22.50*	--------	----	----	*3.50*	--------	*3.50*	----	----	----
6293	----	----	19.90	--------	----	----	1.11	--------	1.11	----	----	----
----	----	----	*20.50*	--------	----	----	*0.75*	--------	*0.75*	----	----	----
6525	----	----	2.85	--------	----	----	2.76	--------	2.76	----	1.08	1.25
6526	----	----	2.75	--------	----	----	2.40	--------	2.47	----	0.92	1.10
----	----	----	*2.75*	--------	----	----	*3.00*	--------	*3.00*	----	*1.20*	----
6536	----	----	9.65	--------	----	----	4.41	--------	4.41	1.57	1.57	0.97
----	----	----	*10.00*	*Bn, T*	----	----	*4.00*	*Bl, Bn, T*	*4.00*	*2.00*	*2.00*	----
6048	----	----	7.15	--------	----	----	8.85	--------	8.85	----	----	----
6373	----	----	7.75	--------	----	----	8.37	--------	8.37	----	----	----
6418	----	----	8.40	--------	----	----	8.11	--------	8.11	----	----	----
6423	----	----	8.55	--------	----	----	8.02	--------	8.02	----	----	----
6434	----	----	8.65	--------	----	----	7.85	--------	7.85	----	----	----
6534	----	----	8.05	--------	----	----	8.10	--------	8.10	----	----	----
6543	----	----	8.65	--------	----	----	7.96	--------	7.96	----	----	----
----	----	----	*8.00*	--------	----	----	*8.00*	--------	*8.00*	----	----	----
6475	----	----	12.75	--------	----	----	7.56	--------	7.56	----	----	----
----	----	----	*11.40*	--------	----	----	*7.40*	--------	*7.40*	----	----	----
6370	----	----	5.15	--------	----	----	9.77	--------	9.77	----	----	----
6371	----	----	4.10	--------	----	----	10.06	--------	10.06	----	----	----
6372	----	----	4.40	--------	----	----	9.93	--------	9.93	----	----	----
6384	----	----	4.90	--------	----	----	9.98	--------	9.98	----	----	----
6447	----	----	4.85	--------	----	----	9.79	--------	9.79	----	----	----
6495	----	----	5.75	--------	----	----	9.37	--------	9.37	----	----	----
----	----	----	*4.00*	--------	----	----	*10.00*	--------	*10.00*	----	----	----
6090	----	----	8.85	--------	----	----	7.40	--------	7.40	----	----	----
6091	----	----	8.35	--------	----	----	7.57	--------	7.57	----	----	----
6185	----	----	19.60	--------	----	----	3.82	--------	3.82	----	----	----
----	----	----	*20.00*	--------	----	----	*3.50*	--------	*3.50*	----	----	----
6184	----	----	7.85	--------	----	----	8.79	--------	8.79	----	----	----
----	----	----	*7.50*	--------	----	----	*8.00*	--------	*8.00*	----	----	----
6181	9.13	1.22	10.35	--------	1.06	2.12	0.97	--------	4.15	9.09	9.09	0.90
----	*7.50*	*1.50*	*9.00*	*Bn, Super, T*	*1.00*	*1.50*	*1.00*	*Bl, Bn, G, T*	*3.50*	*9.00*	*9.00*	----
6187	10.30	1.20	11.50	--------	1.11	2.05	1.04	--------	4.20	5.06	5.06	0.55
----	*7.50*	*1.50*	*9.00*	*Bn, Super, T*	*1.00*	*1.50*	*1.00*	*Bl, Bn, G, T*	*3.50*	*4.50*	*4.50*	----
6179	----	----	----	--------	15.58	----	----	--------	15.58	----	----	----
----	----	----	----	--------	*15.00*	----	----	--------	*15.00*	----	----	----
6180	6.86	2.84	9.70	--------	1.08	2.33	2.79	--------	6.20	2.23	2.23	0.60
----	*5.00*	*2.00*	*7.00*	*Bn, Super, T*	*1.00*	*2.00*	*3.00*	*Bl, Bn, G, T*	*6.00*	*1.50*	*1.50*	----

*6543—60% fine.
*6475—73% fine.
*6370—56% fine.
*6371—77% fine.
*6372—75% fine.
*6384—66% fine.

*6447—63% fine.
*6495—65% fine.
*6090—64% fine.
*6091—71% fine.
*6185—69% fine.
*6184—63% fine.

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Hawaiian Fertilizer Co.—Continued.		
6183	Rape Seed Meal	Lindsay Hay & Grain Co., Lindsay	----
	Guaranteed		----
6182	Special Fall	Lindsay Hay & Grain Co., Lindsay	30.39
	Guaranteed		*26.58*
6165	Superphosphate	Johnson Bros. & Co., Turlock	17.45
	Guaranteed		*15.98*
6186*	Tankage	Lindsay Hay & Grain Co., Lindsay	34.77
	Guaranteed		*33.60*
	Los Angeles Fertilizer Co., Los Angeles, Cal.		
6271	Bat Guano	C. C. Chapman, Fullerton	----
	Sold on Station Analysis.		
6399*	Tankage	A. L. Wright, Jr., Los Angeles	27.77
	Guaranteed		*29.40*
	Mountain Copper Company, San Francisco, Cal.		
6163	Superphosphate	The Grange Co., Turlock	17.84
	Guaranteed		*16.83*
6454	Superphosphate	Chas. H. Low, Riverside	16.51
	Guaranteed		*16.45*
6156	3-10-2	Union Com. Co., Santa Barbara	22.89
	Guaranteed		*23.83*
	Nitrate Agencies Company, Los Angeles, Cal.		
6154	Nitrate of Soda	Sparr Fruit Co., Fillmore	48.67
6158	Nitrate of Soda	H. Booksin, San Jose	48.67
	Guaranteed		*48.00*
	Oakland Meat & Packing Co., Oakland, Cal.		
6387*	Whale Tankage	Alta Cresta Rancho, Riverside	49.60
6436*	Whale Tankage	M. C. Mascart, Redlands	51.74
	Guaranteed		*50.40*

*6186—85% fine. *6387—88% fine.
*6399—61% fine. *6436—85% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6183	----	----	2.40	----------	----	----	4.77	----------	4.77	----	1.07	----
----	----	----	*2.00*	----------	----	----	*5.00*	----------	*5.00*	----	*1.00*	----
6182	11.84	0.16	12.00	----------	----	----	----	----------	----	----	9.63	1.25
----	*7.00*	*5.00*	*12.00*	*Phosphates*	----	----	----	----------	----	*10.00*	*10.00*	----
6165	18.56	0.44	19.00	----------	----	----	----	----------	----	----	----	----
----	*17.00*	*1.00*	*18.00*	----------	----	----	----	----------	----	----	----	----
6186	----	----	15.05	----------	----	----	5.77	----------	5.77	----	----	----
----	----	----	*15.00*	----------	----	----	*5.50*	----------	*5.50*	----	----	----
6271	----	----	6.65	----------	0.57	1.80	5.25	----------	7.62	----	1.91	----
6399	----	----	13.15	----------	----	----	4.42	----------	4.42	----	----	----
----	----	----	*15.00*	----------	----	----	*4.50*	----------	*4.50*	----	----	----
6163	18.98	0.22	19.20	----------	----	----	----	----------	----	----	----	----
----	*17.90*	*0.30*	*18.20*	----------	----	----	----	----------	----	----	----	----
6454	17.56	0.34	17.90	----------	----	----	----	----------	----	----	----	----
----	*17.50*	*0.50*	*18.00*	----------	----	----	----	----------	----	----	----	----
6156	9.84	0.36	10.20	----------	1.67	----	1.21	----------	2.88	----	1.64	1.22
----	*10.00*	*0.25*	*10.25*	*Phosphate of Lime*	*2.00*	----	*1.00*	*Bl*	*3.00*	*2.00*	*2.00*	----
6154	----	----	----	----------	15.21	----	----	----------	15.21	----	----	----
6158	----	----	----	----------	15.21	----	----	----------	15.21	----	----	----
----	----	----	----	----------	*15.00*	----	----	----------	*15.00*	----	----	----
6387	----	----	----	----------	----	----	11.81	----------	11.81	----	----	----
6436	----	----	1.10	----------	----	----	12.32	----------	12.32	----	----	----
----	----	----	----	----------	----	----	*12.00*	----------	*12.00*	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Pacific Bone, Coal and Fertilizing Co., San Francisco, Cal.		
6062	Blood	California Portland Cem't Co., Colton	61.78
	Guaranteed		*61.38*
6300	Blood	Dr. C. S. Lombard, Redlands	61.47
	Guaranteed		*61.78*
6063	Blood	A. F. Call Estate, Corona	----
	Sold on Station Analysis.		
6149*	Bone Meal, Steamed	Orange Hts. Fruit Assn., Corona	35.21
6223*	Bone Meal, Steamed	W. A. Strong et al., Los Angeles	35.71
6328*	Bone Meal, Steamed	Call Lemon Assn., Corona	34.89
6333*	Bone Meal, Steamed	Rialto Orange Co., Rialto	34.78
	Guaranteed		*34.20*
6188	Citrona No. 1	Basil Pryor, Lindsay	34.69
	Guaranteed		*34.10*
6189	Lupine	Basil Pryor, Lindsay	27.82
	Guaranteed		*28.46*
6332	Nitrate of Soda	Rialto Orange Co., Rialto	49.12
	Guaranteed		*48.00*
6331*	Nitrolim Manure	Rialto Orange Co., Rialto	58.56
	Guaranteed		*57.60*
6374*	Tankage	San Jacinto Land Co., Arlington	45.38
6375*	Tankage	San Jacinto Land Co., Arlington	46.41
6516*	Tankage	Orange Hts. Fruit Assn., Corona	40.24
	Guaranteed		*45.35*
6422*	Tankage	W. C. Nickerson, Redlands	34.84
	Guaranteed		*34.30*
6461*	Tankage	So. Cal State Hospital, Patton	34.57
	Guaranteed		*35.70*
6485*	Tankage	C. E. McLaughlin, Rialto	40.22
	Guaranteed		*40.60*
	Pacific Coast Beef and Provision Co., Los Angeles, Cal.		
6431*	Tankage	Geo. H. Cheesman, Walnut	37.59
	Guaranteed		*29.05*
	Pacific Guano and Fertilizer Co., San Francisco, Cal.		
6411	Blood	E. L. Seymour, Highland	58.04
	Guaranteed		*57.86*
6523	Blood	Lorbeer Bros., Pomona	61.42
	Guaranteed		*61.07*
6195*	Bone Meal	D. Ostendorf, Lindsay	38.29
	Guaranteed		*35.34*
6334*	Bone Meal, Steamed	T. J. Dofflemeyer & Sons, Exeter	36.93
	Guaranteed		*36.45*

*6149—60% fine.
*6223—58% fine.
*6328—70% fine.
*6333—65% fine.
*6331—Nitrogen derived from cyanamid.
*6374—80% fine. Contains hoof.
*6375—74% fine. Contains hoof.
*6516—75% fine.
*6422—81% fine.
*6461—70% fine.
*6485—83% fine.
*6431—75% fine.
*6195—56% fine.
*6334—71% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6062	----	----	----	----	----	----	14.04	----	14.04	----	----	----
----	----	----	----	----	----	----	*13.95*	----	*13.95*	----	----	----
6300	----	----	----	----	----	----	13.97	----	13.97	----	----	----
----	----	----	----	----	----	----	*14.04*	----	*14.04*	----	----	----
6063	----	----	----	----	----	----	13.81	----	13.81	----	----	----
6149	----	----	23.40	----	----	----	3.37	----	3.37	----	----	----
6223	----	----	23.90	----	----	----	3.38	----	3.38	----	----	----
6328	----	----	24.30	----	----	----	3.10	----	3.10	----	----	----
6333	----	----	23.80	----	----	----	3.18	----	3.18	----	----	----
----	----	----	*24.00*	----	----	----	*3.00*	----	*3.00*	----	----	----
6188	7.41	3.64	11.05	----	1.54	----	1.39	----	2.93	6.99	6.99	0.60
----	*7.00*	*3.00*	*10.00*	*Bn, Super*	*1.50*	----	*1.50*	*Bl, Bn, T*	*3.00*	*7.00*	*7.00*	----
6189	8.47	1.08	9.55	----	----	----	----	----	----	9.93	9.93	0.65
----	*9.00*	*1.00*	*10.00*	*Super*	----	----	----	----	----	*10.00*	*10.00*	----
6332	----	----	----	----	15.35	----	----	----	15.35	----	----	----
----	----	----	----	----	*15.00*	----	----	----	*15.00*	----	----	----
6331	----	----	----	----	----	----	----	----	18.30	----	----	----
----	----	----	----	----	----	----	----	----	18.00	----	----	----
6374	----	----	4.35	----	----	----	10.08	----	10.08	----	----	----
6375	----	----	5.70	----	----	----	10.10	----	10.10	----	----	----
6516	----	----	5.10	----	----	----	8.73	----	8.73	----	----	----
----	----	----	*5.50*	----	----	----	*9.88*	----	*9.88*	----	----	----
6422	----	----	13.05	----	----	----	6.12	----	6.12	----	----	----
----	----	----	*13.00*	----	----	----	*6.00*	----	*6.00*	----	----	----
6461	----	----	3.25	----	----	----	7.69	----	7.69	----	----	----
----	----	----	*3.00*	----	----	----	*8.00*	----	*8.00*	----	----	----
6485	----	----	9.10	----	----	----	8.06	----	8.06	----	----	----
----	----	----	*10.00*	----	----	----	*8.00*	----	*8.00*	----	----	----
6431	----	----	9.30	----	----	----	7.40	----	7.40	----	----	----
----	----	----	*8.50*	----	----	----	*5.50*	----	*5.50*	----	----	----
6411	----	----	----	----	----	----	13.19	----	13.19	----	----	----
----	----	----	----	----	----	----	*13.15*	----	*13.15*	----	----	----
6523	----	----	----	----	----	----	13.96	----	13.96	----	----	----
----	----	----	----	----	----	----	*13.88*	----	*13.88*	----	----	----
6195	----	----	22.90	----	----	----	4.21	----	4.21	----	----	----
----	----	----	*22.00*	----	----	----	*3.70*	----	*3.70*	----	----	----
6334	----	----	23.30	----	----	----	3.80	----	3.80	----	----	----
----	----	----	*23.00*	----	----	----	*3.75*	----	*3.75*	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Pacific Guano and Fertilizer Co.— Continued.		
6193	Diamond F and V	D. Ostendorf, Lindsay	35.29
6197	Diamond F and V	F. Ostendorf, Lindsay	35.34
	Guaranteed		*33.00*
6194	Diamond N	D. Ostendorf, Lindsay	31.52
	Guaranteed		*27.90*
6196	Diamond PP	D. Ostendorf, Lindsay	29.56
	Guaranteed		*29.28*
6192	Nitrate of Soda	D. Ostendorf, Lindsay	48.96
	Guaranteed		*48.00*
6123	O.K.	T. Miyazaki, San Juan	42.42
	Guaranteed		*45.80*
6412	Special	A. C. Moll, San Bernardino	24.62
6524	Special	E. F. Struve, Pomona	25.06
	Guaranteed		*24.75*
6416	Special	Hugh Latimer, Arlington	26.80
6488	Special	Hugh Latimer, Arlington	26.92
	Guaranteed		*26.85*
6547	Special	E. E. Cole, Redlands	24.72
	Guaranteed		*23.90*
6162	Superphosphate Gaviota Cresco	T. E. Wilson, Ceres	17.71
6267	Superphosphate Cresco	Smith & Miner, Santa Ana	17.17
6443	Superphosphate Cresco	P. B. Goethals, Arlington	16.07
	Guaranteed		*15.98*
6410*	Tankage	D. W. Divine, Highland	34.06
	Guaranteed		*33.08*
6424*	Tankage	J. D. Boley et al., Highland	33.95
	Guaranteed		*32.94*
6484*	Tankage	C. E. McLaughlin, Rialto	41.45
	Guaranteed		*41.67*
	Pacific Reduction Co., Los Angeles, Cal.		
6409*	Organic Tankage	W. M. Warren, Covina	----
6445*	Organic Tankage	M. T. Durrell, Azusa	----
6497*	Organic Tankage	W. M. Baird, Duarte	----
6507*	Organic Tankage	W. M. Baird, Duarte	----
6509*	Organic Tankage	Chas. H. Low, Riverside	----
6522*	Organic Tankage	S. M. L. Cit. Assn., Lamanda Park	----
6535*	Organic Tankage	Curtis Ranch Co., Bloomington	----
	Guaranteed		----

*6410—83% fine.
*6424—93% fine.
*6484—79% fine.
*6409—32% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6445—37% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6497—31% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6507—36% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6509—34% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6522—41% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6535—41% fine. In absence of market quotations no prices are given on Garbage Tankage.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6193	8.80	2.30	11.10	--------	0.62	----	2.10	--------	2.72	7.25	7.25	0.67
6197	8.68	1.92	10.60	--------	0.59	----	2.24	--------	2.83	7.25	7.25	0.52
----	*8.00*	*2.00*	*10.00*	*Bn, G, Super*	*0.50*	----	*2.00*	*Bl, Bn, T, Fs, G*	*2.50*	*7.00*	*7.00*	----
6194	8.89	1.26	10.15	--------	0.96	----	3.47	--------	4.43	2.37	2.37	----
----	*8.00*	*1.00*	*9.00*	*Bn, Super*	*1.00*	----	*3.00*	*Bl, Bn, Fs*	*4.00*	*2.00*	*2.00*	----
6196	12.40	0.80	13.20	--------	----	----	----	--------	----	8.95	8.95	0.70
----	*12.00*	*1.00*	*13.00*	*Super*	----	----	----	--------	----	*9.00*	*9.00*	----
6192	----	----	----	--------	15.30	----	----	--------	15.30	----	----	----
----	----	----	----	--------	*15.00*	----	----	--------	*15.00*	----	----	----
6123	7.30	0.60	7.90	--------	2.52	----	2.05	--------	4.57	9.32	9.32	0.82
----	*7.00*	*1.00*	*8.00*	*Bn, Super, G*	*3.00*	----	*2.00*	*Bl, Bn, G, T*	*5.00*	*10.00*	*10.00*	----
6412	----	----	10.60	--------	1.66	----	2.83	--------	4.49	----	0.54	0.95
6524	----	----	10.65	--------	1.46	----	3.08	--------	4.54	----	0.58	1.07
----	----	----	*10.50*	*Bn, Super*	*1.50*	----	*3.00*	*Bn, T*	*4.50*	*0.50*	*0.50*	----
6416	----	----	10.75	--------	1.27	----	3.11	--------	4.38	----	0.85	0.97
6488	----	----	10.85	--------	1.62	----	2.85	--------	4.47	----	0.79	1.00
----	----	----	*10.50*	*Bn, Super*	*1.50*	----	*3.00*	*Bn, T*	*4.50*	*0.50*	*0.50*	----
6547	7.17	0.78	7.95	--------	1.27	0.30	1.48	--------	3.05	----	3.16	1.60
----	*7.00*	----	*7.00*	*G, Super*	*1.00*	----	*2.00*	*G, T*	*3.00*	*3.00*	*3.00*	----
6162	18.84	0.36	19.20	--------	----	----	----	--------	----	----	----	----
6267	18.28	0.22	18.50	--------	----	----	----	--------	----	----	----	----
6443	17.10	0.60	17.70	--------	----	----	----	--------	----	----	----	----
----	*17.00*	*1.00*	*18.00*	--------	----	----	----	--------	----	----	----	----
6410	----	----	16.55	--------	----	----	5.35	--------	5.35	----	----	----
----	----	----	*15.75*	--------	----	----	*5.25*	--------	*5.25*	----	----	----
6424	----	----	20.30	--------	----	----	4.70	--------	4.70	----	----	----
----	----	----	*19.75*	--------	----	----	*4.55*	--------	*4.55*	----	----	----
6484	----	----	9.00	--------	----	----	8.37	--------	8.37	----	----	----
----	----	----	*8.95*	--------	----	----	*8.43*	--------	*8.43*	----	----	----
6409	----	----	2.65	--------	----	----	3.07	--------	3.07	----	1.23	1.27
6445	----	----	3.00	--------	----	----	3.10	--------	3.10	----	1.18	1.17
6497	----	----	2.45	--------	----	----	3.05	--------	3.05	----	1.52	1.35
6507	----	----	2.25	--------	----	----	2.88	--------	2.88	----	1.26	1.40
6509	----	----	2.15	--------	----	----	2.68	--------	2.68	----	1.27	1.20
6522	----	----	2.25	--------	----	----	3.17	--------	3.17	----	1.24	1.45
6535	----	----	2.10	--------	----	----	2.92	--------	2.92	----	1.36	1.37
----	----	----	*2.75*	--------	----	----	*3.00*	--------	*3.00*	----	*1.25*	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Redlands Fruit Association, Redlands, Cal.		
6050	Dried Blood	Elmer Hayward, Orange	60.37
	Guaranteed		*58.08*
	Swift & Company, Chicago, Ill.		
6088*	Tankage	B. L. Byer, Upland	32.75
	Guaranteed		*32.20*
	Union Fertilizer Co., Los Angeles, Cal.		
6065	Fruiting	H. C. Lash, Rialto	26.40
6089	Fruiting	E. G. Generent, Corona	25.84
6128	Fruiting	E. E. Cole, Redlands	26.05
6133	Fruiting	H. O. Blohm, Upland	25.89
6323	Fruiting	E. E. Cole, Redlands	27.76
6363	Fruiting	F. Bebermeyer, Orange	25.83
6390	Fruiting	Geo. R. Tyler, Pomona	27.43
6415	Fruiting	H. C. Lash, Rialto	29.03
	Guaranteed		*24.90*
6066	Nursery	H. C. Lash, Rialto	31.41
6127	Nursery	E. E. Cole, Redlands	29.61
6324	Nursery	E. E. Cole, Redlands	29.82
6391	Nursery	Geo. R. Tyler, Pomona	32.28
	Guaranteed		*28.75*
6496*	Rock Phosphate	Wright Bros., Riverside	----
	Guaranteed		----
	Union Superphosphate Co., San Francisco, Cal.		
6153	Superphosphate	Sparr Fruit Co., Fillmore	17.38
	Guaranteed		*15.98*
	Western Fertilizer Co., San Francisco, Cal.		
6230*	Wizard	Nance & Tater, Porterville	33.12
6283*	Wizard	Riverside Milling Co., Riverside	36.76
	Guaranteed		*44.40*
6252*	Wizard	C. H. Nearpass, San Diego	38.58
	Guaranteed		*43.30*

*6088—58% fine.
*6496—36% fine. Through 100 mesh sieve.
*6230—No statement of derivation. In violation of the California Fertilizer Act.
*6283—No statement of derivation. In violation of the California Fertilizer Act.
*6252—No statement of derivation. In violation of the California Fertilizer Act.

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Laboratory Number	PHOSPHORIC ACID — Available	Insoluble	Total	Guaranteed as derived from	NITROGEN — In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	POTASH — From sulfate	Total	CHLORIN
6050	----	----	----	--------	----	----	13.72	--------	13.72	----	----	----
----	----	----	----	--------	----	----	*13.20*	--------	*13.20*	----	----	----
6088	----	----	24.10	--------	----	----	3.78	--------	3.78	----	----	----
----	----	----	*22.00*	--------	----	----	*4.00*	--------	*4.00*	----	----	----
6065	7.23	1.32	8.55	--------	1.27	----	1.89	--------	3.16	----	3.35	0.95
6089	6.77	1.58	8.35	--------	0.37	0.90	1.88	--------	3.15	----	3.18	0.90
6128	6.36	1.14	7.50	--------	0.83	0.38	2.05	--------	3.26	----	3.41	0.77
6133	6.99	0.96	7.95	--------	1.33	----	1.89	--------	3.22	----	3.27	1.10
6323	6.02	2.68	8.70	--------	1.23	----	2.26	--------	3.49	----	3.25	0.92
6363	6.10	2.30	8.40	--------	1.07	----	2.01	--------	3.08	----	3.20	0.60
6390	6.25	2.60	8.85	--------	1.10	----	2.24	--------	3.34	----	3.27	0.55
6415	6.75	2.70	9.45	--------	0.39	0.93	2.31	--------	3.63	----	3.30	1.00
----	*7.00*	*1.50*	*8.50*	*Bn, Super, G, T*	*0.75*	*0.60*	*1.65*	*Bn, G, T*	*3.00*	----	*3.00*	----
6066	6.58	0.72	7.30	--------	1.71	----	3.46	--------	5.17	----	2.42	0.87
6127	5.57	2.38	7.95	--------	1.81	----	3.09	--------	4.90	----	1.84	----
6324	5.23	2.82	8.05	--------	2.10	----	2.88	--------	4.98	----	1.88	0.57
6391	6.12	1.78	7.90	--------	1.50	0.49	3.46	--------	5.46	----	2.12	1.02
----	*6.00*	*1.50*	*7.50*	*Bn, Super G, T*	*1.00*	*1.00*	*3.00*	*Bn, G, T*	*5.00*	----	*1.50*	----
6496	----	----	32.00	--------	----	----	----	--------	----	----	----	----
----	----	----	*34.00*	--------	----	----	----	--------	----	----	----	----
6153	18.50	0.30	18.80	--------	----	----	----	--------	----	----	----	----
----	*17.00*	*1.00*	*18.00*	--------	----	----	----	--------	----	----	----	----
6230	6.23	2.92	9.15	--------	4.67	----	----	--------	4.67	4.97	4.97	0.60
6282	6.81	2.14	8.95	--------	5.92	----	----	--------	5.92	----	4.88	0.62
----	*8.00*	----	----	--------	----	----	----	--------	*6.00*	*6.00*	*6.00*	----
6252	9.42	1.08	10.50	--------	6.26	----	----	--------	6.26	----	4.55	0.65
----	*9.00*	----	----	--------	----	----	----	--------	*6.00*	*5.00*	*5.00*	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Western Meat Company, San Francisco, Cal.		
6084	Blood, Diamond H	Dr. J. S. Carroll, Pomona	62.08
	Guaranteed		*63.71*
6093	Blood, Diamond H	J. Henry Reynolds, Redlands	61.95
	Guaranteed		*61.91*
6104	Blood, Diamond H	B. L. Byer, Upland	60.81
	Guaranteed		*64.02*
6289	Blood, Diamond H	H. D. Derwin, Upland	60.59
	Guaranteed		*59.88*
6294	Blood, Diamond H	Fruit Growers Supply Co., Los An.	54.91
6295	Blood, Diamond H	Redlands Fruit Assn., Redlands	55.44
6296	Blood, Diamond H	Fruit Growers Supply Co., Los An.	55.13
	Guaranteed		*54.21*
6318	Blood, Diamond H	J. H. Reynolds, Redlands	61.16
	Guaranteed		*59.75*
6319	Blood, Diamond H	J. H. Reynolds, Redlands	61.42
	Guaranteed		*62.22*
6368	Blood, Diamond H	E. L. Koethen, Riverside	61.42
	Guaranteed		*60.37*
6521	Blood, Diamond H	C. L. Nickle, Glendora	59.58
	Guaranteed		*59.40*
6528	Blood, Diamond H	Chas. Page, Covina	61.34
	Guaranteed		*62.92*
6347*	Bone Meal	Benchley Fruit Co., Fullerton	36.04
	Guaranteed		*35.10*
6161*	Bone Meal, Diamond G	J. S. West, Modesto	32.68
	Guaranteed		*32.85*
6234*	Bone Meal, Diamond G	Bakersfield Sandst. Brick Co., B'field	33.09
	Guaranteed		*33.06*
6270*	Bone Meal, Diamond G	C. L. Nickle, Glendora	34.63
6376*	Bone Meal, Diamond G	E. L. Koethen, Riverside	35.18
	Guaranteed		*32.70*
6095*	Bone Meal Special	J. H. Reynolds, Redlands	33.37
	Guaranteed		*32.70*
6135*	Bone Meal Special	P. J. Neilly, Pomona	34.02
	Guaranteed		*33.06*
6551*	Bone Meal Special	Alta Cresta Rancho, Riverside	31.18
	Guaranteed		*30.30*
6164	Diamond B	Knutsen Bros., Turlock	33.64
	Guaranteed		*30.40*
6345	Diamond C	Benchley Fruit Co., Fullerton	33.57
	Guaranteed		*33.15*
6469	Diamond D	B. L. Byer, Upland	30.96
	Guaranteed		*26.80*

*6347—59% fine.
*6161—85% fine.
*6234—91% fine.
*6270—74% fine.
*6376—77% fine.
*6095—66% fine.
*6135—76% fine.
*6551—49% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6084	----	----	----	----------	----	----	14.11	----------	14.11	----	----	----
----	----	----	----	----------	----	----	*14.48*	----------	*14.48*	----	----	----
6093	----	----	----	----------	----	----	14.08	----------	14.08	----	----	----
----	----	----	----	----------	----	----	*14.07*	----------	*14.07*	----	----	----
6104	----	----	----	----------	----	----	13.82	----------	13.82	----	----	----
----	----	----	----	----------	----	----	*14.55*	----------	*14.55*	----	----	----
6289	----	----	----	----------	----	----	13.77	----------	13.77	----	----	----
----	----	----	----	----------	----	----	*13.61*	----------	*13.61*	----	----	----
6294	----	----	----	----------	----	----	12.48	----------	12.48	----	----	----
6295	----	----	----	----------	----	----	12.60	----------	12.60	----	----	----
6296	----	----	----	----------	----	----	12.53	----------	12.53	----	----	----
----	----	----	----	----------	----	----	*12.32*	----------	*12.32*	----	----	----
6318	----	----	----	----------	----	----	13.90	----------	13.90	----	----	----
----	----	----	----	----------	----	----	*13.58*	----------	*13.58*	----	----	----
6319	----	----	----	----------	----	----	13.96	----------	13.96	----	----	----
----	----	----	----	----------	----	----	*14.14*	----------	*14.14*	----	----	----
6368	----	----	----	----------	----	----	13.96	----------	13.96	----	----	----
----	----	----	----	----------	----	----	*13.72*	----------	*13.72*	----	----	----
6521	----	----	----	----------	----	----	13.54	----------	13.54	----	----	----
----	----	----	----	----------	----	----	*13.50*	----------	*13.50*	----	----	----
6528	----	----	----	----------	----	----	13.94	----------	13.94	----	----	----
----	----	----	----	----------	----	----	*14.30*	----------	*14.30*	----	----	----
6347	----	----	25.20	----------	----	----	3.18	----------	3.18	----	----	----
----	----	----	*25.00*	----------	----	----	*3.00*	----------	*3.00*	----	----	----
6161	----	----	32.20	----------	----	----	0.88	----------	0.88	----	----	----
----	----	----	*32.30*	----------	----	----	*0.90*	----------	*0.90*	----	----	----
6234	----	----	32.80	----------	----	----	0.85	----------	0.85	----	----	----
----	----	----	*33.00*	----------	----	----	*0.80*	----------	*0.80*	----	----	----
6270	----	----	29.10	----------	----	----	2.01	----------	2.01	----	----	----
6376	----	----	27.80	----------	----	----	2.42	----------	2.42	----	----	----
----	----	----	*27.00*	----------	----	----	*2.00*	----------	*2.00*	----	----	----
6095	----	----	27.70	----------	----	----	2.01	----------	2.01	----	----	----
----	----	----	*27.00*	----------	----	----	*2.00*	----------	*2.00*	----	----	----
6135	----	----	33.60	----------	----	----	0.90	----------	0.90	----	----	----
----	----	----	*33.70*	----------	----	----	*0.65*	----------	*0.65*	----	----	----
6551	----	----	22.60	----------	----	----	2.58	----------	2.58	----	----	----
----	----	----	*22.00*	----------	----	----	*2.50*	----------	*2.50*	----	----	----
6164	7.24	3.76	11.00	----------	----	----	3.18	----------	3.18	5.19	5.19	1.50
----	*9.00*	*2.00*	*11.00*	*Bn, Super*	----	----	*2.50*	*Animal Matter*	*2.50*	*5.00*	*5.00*	----
6345	5.80	3.70	9.50	----------	----	----	3.69	----------	3.69	4.76	4.76	0.80
----	*7.00*	*2.50*	*9.50*	*Bn, Super*	----	----	*3.00*	*Animal Matter*	*3.00*	*6.00*	*6.00*	----
6469	6.37	6.78	13.15	----------	----	----	3.09	----------	3.09	4.39	4.39	1.55
----	*8.00*	*2.00*	*10.00*	*Bn, Super*	*1.00*	----	*3.00*	*Animal Matter*	*4.00*	*2.00*	*2.00*	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Western Meat Company— Continued.		
6464*	Garbage Tankage	B. C. Swartz, Bloomington	----
	Guaranteed		----
6157	Lemon Special	Johnston Fruit Co., Santa Barbara	29.73
	Guaranteed		*26.13*
6364	Nitrate of Soda	E. L. Koethen, Riverside	48.22
	Guaranteed		*48.00*
6085	Special	B. L. Byer, Upland	34.79
	Guaranteed		*33.80*
6107	Special	B. L. Byer, Upland	35.74
	Guaranteed		*34.40*
6108	Special	B. L. Byer, Upland	41.77
	Guaranteed		*39.80*
6113	Special	J. H. Reynolds, Redlands	36.19
	Guaranteed		*34.80*
6115	Special	J. H. Reynolds, Redlands	29.92
	Guaranteed		*28.80*
6369	Special	E. L. Koethen, Riverside	30.31
	Guaranteed		*26.80*
6386*	Special	L. G. Baldwin, Upland	45.37
	Guaranteed		*43.40*
6394*	Special	F. D. Parker et al., San Fernando	32.00
6480*	Special	R. H. Gibson, San Fernando	31.78
	Guaranteed		*30.66*
6517	Special	Orange Hts. Fruit Assn., Corona	26.11
	Guaranteed		*27.60*
6546	Special	J. H. Reynolds, Redlands	30.98
	Guaranteed		*29.80*
6105	Superphosphate	B. L. Byer, Upland	16.66
	Guaranteed		*15.98*
6049*	Tankage	Alta Cresto Rancho, Riverside	42.56
	Guaranteed		*41.65*
6086*	Tankage	B. L. Byer, Upland	36.41
6467*	Tankage	B. L. Byer, Upland	38.35
	Guaranteed		*35.70*
6096*	Tankage	J. H. Reynolds, Redlands	43.37
	Guaranteed		*42.70*
6097*	Tankage	J. H. Reynolds, Redlands	38.28
	Guaranteed		*38.15*

*6464—36% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6386—72% fine. *6086—76% fine.
*6394—63% fine as bone, 88% fine as tankage. *6467—82% fine.
*6480—86% fine. *6096—81% fine.
*6049—80% fine. *6097—71% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6464	----	----	2.55	---------	----	----	3.10	---------	3.10	----	1.27	1.20
----	----	----	*2.75*	---------	----	----	*3.00*	---------	*3.00*	----	*1.25*	----
6157	7.32	2.08	9.90	---------	2.20	0.72	1.48	---------	4.40	2.63	2.63	----
----	*8.00*	*2.00*	*10.00*	*Bn, Super*	*2.35*	*0.75*	*1.00*	*Animal Matter*	*4.10*	*1.50*	*1.50*	----
6364	----	----	----	---------	15.07	----	----	---------	15.07	----	----	----
----	----	----	----	---------	*15.00*	----	----	---------	*15.00*	----	----	----
6085	----	----	10.15	---------	1.83	----	2.19	---------	4.02	5.30	5.30	0.65
----	----	----	*10.00*	*Bn, Super*	*2.00*	----	*2.00*	*Animal Matter*	*4.00*	*5.00*	*5.00*	----
6107	----	----	7.90	---------	----	2.06	4.00	---------	6.06	2.62	2.62	1.00
----	----	----	*8.00*	*Bn, Super*	----	*2.00*	*4.00*	*Animal Matter*	*6.00*	*2.00*	*2.00*	----
6108	----	----	9.40	---------	----	----	4.54	---------	4.54	7.12	7.12	0.82
----	----	----	*10.00*	*Bn*	----	----	*4.00*	*Animal Matter*	*4.00*	*7.00*	*7.00*	----
6113	----	----	9.60	---------	1.17	----	3.03	---------	4.20	5.54	5.54	1.62
----	----	----	*10.00*	*Bn, Super*	*1.00*	----	*3.00*	*Animal Matter*	*4.00*	*5.00*	*5.00*	----
6115	----	----	9.55	---------	0.91	----	2.86	---------	3.77	3.20	3.20	1.32
----	----	----	*10.00*	*Bn, Super*	*1.00*	----	*3.00*	*Animal Matter*	*4.00*	*2.00*	*2.00*	----
6369	----	----	9.65	---------	2.86	0.62	1.16	---------	4.64	2.81	2.81	0.85
----	----	----	*10.00*	*Bn*	*2.25*	*0.75*	*1.00*	*Animal Matter*	*4.00*	*2.00*	*2.00*	----
6386	----	----	14.30	---------	----	----	8.42	---------	8.42	----	----	----
----	----	----	*14.00*	*Bn*	----	----	*8.00*	*Animal Matter*	*8.00*	----	----	----
6394	----	----	17.03	---------	----	----	4.78	---------	4.78	----	----	----
6480	----	----	17.80	---------	----	----	4.60	---------	4.60	----	----	----
----	----	----	*18.00*	*Bn*	----	----	*4.30*	*Animal Matter*	*4.30*	----	----	----
6517	----	----	9.45	---------	----	----	2.90	---------	2.90	2.71	2.71	0.85
----	----	----	*10.00*	*Bn*	----	----	*3.00*	*Animal Matter*	*3.00*	*3.00*	*3.00*	----
6546	----	----	10.30	---------	----	----	3.86	---------	3.86	2.75	2.75	1.55
----	----	----	*10.00*	*Bn*	----	----	*4.00*	*Animal Matter*	*4.00*	*2.00*	*2.00*	----
6105	17.72	0.58	18.30	---------	----	----	----	---------	----	----	----	----
----	*17.00*	*1.00*	*18.00*	---------	----	----	----	---------	----	----	----	----
6049	----	----	8.60	---------	----	----	8.70	---------	8.70	----	----	----
----	----	----	*8.50*	---------	----	----	*8.50*	---------	*8.50*	----	----	----
6086	----	----	9.30	---------	----	----	7.12	---------	7.12	----	----	----
6467	----	----	8.95	---------	----	----	7.64	---------	7.64	----	----	----
----	----	----	*9.00*	---------	----	----	*7.00*	---------	*7.00*	----	----	----
6096	----	----	9.15	---------	----	----	8.80	---------	8.80	----	----	----
----	----	----	*8.80*	---------	----	----	*8.70*	---------	*8.70*	----	----	----
6097	----	----	12.15	---------	----	----	7.09	---------	7.09	----	----	----
----	----	----	*11.00*	---------	----	----	*7.25*	---------	*7.25*	----	----	----

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Western Meat Company— Continued.		
6106*	Tankage	B. L. Byer, Upland	32.49
6508*	Tankage	P. A. Demmens, Alta Loma	32.51
	Guaranteed		*31.50*
6114*	Tankage	J. H. Reynolds, Redlands	42.62
	Guaranteed		*42.28*
6310*	Tankage	Orange Hts. Fruit Assn., Corona	41.16
6311*	Tankage	Santiago Orange Growers Assn, Orange	40.63
6312*	Tankage	Fruit Growers Supply Co., Los Angeles	40.91
	Guaranteed		*43.05*
6314*	Tankage	J. H. Reynolds, Redlands	44.85
	Guaranteed		*45.85*
6315*	Tankage	J. H. Reynolds, Redlands	35.39
	Guaranteed		*36.27*
6316*	Tankage	J. H. Reynolds, Redlands	40.04
	Guaranteed		*39.97*
6317*	Tankage	J. H. Reynolds, Redlands	43.16
	Guaranteed		*44.09*
6326*	Tankage	Stewart Cit. Assn., Upland	45.05
6356*	Tankage	Stewart Cit. Assn., Upland	46.19
	Guaranteed		*46.06*
6346*	Tankage	Benchley Fruit Co., Fullerton	43.43
	Guaranteed		*43.24*
6353*	Tankage	Stewart Cit. Assn., Upland	45.16
	Guaranteed		*45.75*
6365*	Tankage	E. L. Koethen, Riverside	40.47
6385*	Tankage	T. K. Vernon, Upland	38.44
6468*	Tankage	B. L. Byer, Upland	38.80
6494*	Tankage	G. L. Hutchinson, Colton	40.30
	Guaranteed		*39.20*
6366*	Tankage	E. L. Koethen, Riverside	43.67
6432*	Tankage	F. G. Bush, Ontario	43.54
	Guaranteed		*43.23*
6367*	Tankage	E. L. Koethen, Riverside	44.14
	Guaranteed		*44.21*
6470*	Tankage	C. Huber, Los Angeles	34.05
	Guaranteed		*33.46*
6490*	Tankage	H. D. Derwin, Upland	42.93
	Guaranteed		*44.07*
6498*	Tankage	Elmer Hayward, Orange	42.69
	Guaranteed		*40.85*
6518*	Tankage	H. D. Derwin, Upland	45.77
	Guaranteed		*46.03*
6519*	Tankage	Orange Hts. Fruit Assn., Corona	41.20
	Guaranteed		*40.95*

*6106—85% fine.
*6508—84% fine.
*6114—79% fine.
*6310—81% fine.
*6311—81% fine.
*6312—81% fine.
*6314—76% fine.
*6315—79% fine.
*6316—76% fine.
*6317—76% fine.
*6326—83% fine.
*6356—79% fine.
*6346—77% fine.
*6353—78% fine.
*6365—81% fine.
*6385—87% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6106	----	----	15.15	----------	----	----	5.21	----------	5.21	----	----	----
6508	----	----	14.40	----------	----	----	5.34	----------	5.34	----	----	----
----	----	----	*15.00*	----------	----	----	*5.00*	----------	*5.00*	----	----	----
6114	----	----	7.90	----------	----	----	8.83	----------	8.83	----	----	----
----	----	----	*8.80*	----------	----	----	*8.60*	----------	*8.60*	----	----	----
6310	----	----	13.50	----------	----	----	7.55	----------	7.55	----	----	----
6311	----	----	13.70	----------	----	----	7.39	----------	7.39	----	----	----
6312	----	----	13.80	----------	----	----	7.44	----------	7.44	----	----	----
----	----	----	*13.50*	----------	----	----	*8.00*	----------	*8.00*	----	----	----
6314	----	----	7.85	----------	----	----	9.37	----------	9.37	----	----	----
----	----	----	*6.40*	----------	----	----	*9.85*	----------	*9.85*	----	----	----
6315	----	----	11.20	----------	----	----	6.56	----------	6.56	----	----	----
----	----	----	*11.50*	----------	----	----	*6.72*	----------	*6.72*	----	----	----
6316	----	----	11.00	----------	----	----	7.70	----------	7.70	----	----	----
----	----	----	*11.50*	----------	----	----	*7.60*	----------	*7.60*	----	----	----
6317	----	----	7.90	----------	----	----	8.96	----------	8.96	----	----	----
----	----	----	*7.79*	----------	----	----	*9.20*	----------	*9.20*	----	----	----
6326	----	----	7.00	----------	----	----	9.56	----------	9.56	----	----	----
6356	----	----	7.55	----------	----	----	9.74	----------	9.74	----	----	----
----	----	----	*7.00*	----------	----	----	*9.80*	----------	*9.80*	----	----	----
6346	----	----	8.40	----------	----	----	8.94	----------	8.94	----	----	----
----	----	----	*8.61*	----------	----	----	*8.86*	----------	*8.86*	----	----	----
6353	----	----	7.75	----------	----	----	9.46	----------	9.46	----	----	----
----	----	----	*7.15*	----------	----	----	*9.70*	----------	*9.70*	----	----	----
6365	----	----	8.55	----------	----	----	8.21	----------	8.21	----	----	----
6385	----	----	9.50	----------	----	----	7.57	----------	7.57	----	----	----
6468	----	----	8.15	----------	----	----	7.88	----------	7.88	----	----	----
6494	----	----	11.25	----------	----	----	7.72	----------	7.72	----	----	----
----	----	----	*8.00*	----------	----	----	*8.00*	----------	*8.00*	----	----	----
6366	----	----	9.10	----------	----	----	8.88	----------	8.88	----	----	----
6432	----	----	8.80	----------	----	----	8.90	----------	8.90	----	----	----
----	----	----	*8.00*	----------	----	----	*8.96*	----------	*8.96*	----	----	----
6367	----	----	7.50	----------	----	----	9.26	----------	9.26	----	----	----
----	----	----	*7.36*	----------	----	----	*9.30*	----------	*9.30*	----	----	----
6470	----	----	14.50	----------	----	----	5.69	----------	5.69	----	----	----
----	----	----	*15.40*	----------	----	----	*5.40*	----------	*5.40*	----	----	----
6490	----	----	7.45	----------	----	----	8.98	----------	8.98	----	----	----
----	----	----	*6.55*	----------	----	----	*9.40*	----------	*9.40*	----	----	----
6498	----	----	7.40	----------	----	----	8.93	----------	8.93	----	----	----
----	----	----	*8.50*	----------	----	----	*8.31*	----------	*8.31*	----	----	----
6518	----	----	6.35	----------	----	----	9.84	----------	9.84	----	----	----
----	----	----	*6.30*	----------	----	----	*9.91*	----------	*9.91*	----	----	----
6519	----	----	12.95	----------	----	----	7.65	----------	7.65	----	----	----
----	----	----	*13.50*	----------	----	----	*7.50*	----------	*7.50*	----	----	----

*6468—90% fine.
*6494—78% fine.
*6366—79% fine.
*6432—89% fine.
*6367—76% fine.

*6470—86% fine.
*6490—86% fine.
*6498—83% fine.
*6518—71% fine.
*6519—76% fine.

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Laboratory Number	Name and Address of Manufacturer or Dealer, and Name of Brand.	From Whom Obtained.	Value per Ton at Station Prices.
	Western Meat Company— Continued.		
6540*	Tankage	W. J. Naftel, Pomona	34.24
	Guaranteed		*31.86*
6552*	Tankage	T. E. Ketcheson, Upland	43.06
	Guaranteed		*43.37*
6112*	Tankage, Diamond E	J. H. Reynolds, Redlands	33.53
6545*	Tankage, Diamond E	J. H. Reynolds, Redlands	36.15
	Guaranteed		*33.60*
6094*	Tankage, Diamond I	J. H. Reynolds, Redlands	32.33
6215*	Tankage, Diamond I	Bakersfield Sandst. Brick Co., B'field	31.16
	Guaranteed		*32.10*
6437	Whale Blood Meal	W. A. Strong, Upland	49.60
	Guaranteed		*50.40*

*6540—43% fine.
*6552—78% fine.
*6112—81% fine.
*6545—86% fine.
*6094—75% fine.
*6215—80% fine.

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Laboratory Number	PHOSPHORIC ACID				NITROGEN					POTASH		CHLORIN
	Available	Insoluble	Total	Guaranteed as derived from	In Nitrates	In Ammonia Salts	Organic	Organic Nitrogen guaranteed as derived from	Total	From sulfate	Total	
6540	----	----	14.35	--------	----	----	5.76	--------	5.76	----	----	----
----	----	----	*14.80*	--------	----	----	*5.12*	--------	*5.12*	----	----	----
6552	----	----	8.30	--------	----	----	8.87	--------	8.87	----	----	----
----	----	----	*7.35*	--------	----	----	*9.10*	--------	*9.10*	----	----	----
6112	----	----	16.40	--------	----	----	5.25	--------	5.25	----	----	----
6545	----	----	19.90	--------	----	----	5.29	--------	5.29	----	----	----
----	----	----	*18.00*	--------	----	----	*5.00*	--------	*5.00*	----	----	----
6094	----	----	13.25	--------	----	----	5.49	--------	5.49	----	----	----
6215	----	----	12.00	--------	----	----	5.42	--------	5.42	----	----	----
----	----	----	*13.75*	--------	----	----	*5.35*	--------	*5.35*	----	----	----
6437	----	----	----	--------	----	----	11.81	--------	11.81	----	----	----
----	----	----	----	--------	----	----	*12.00*	--------	*12.00*	----	----	----

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COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

PRELIMINARY REPORT

ON

KEARNEY VINEYARD EXPERIMENTAL DRAIN

FRESNO COUNTY, CALIFORNIA

BY

WALTER W. WEIR

Senior Drainage Engineer, U. S. Department of Agriculture

(Based on work done under a co-operative agreement between the Office of Public Roads and Rural Engineering, U. S. Department of Agriculture, and the University of California Agricultural Experiment Station.)

BULLETIN No. 273

November, 1916

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY
1916

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THE COMMON HONEY BEE AS AN AGENT IN PRUNE POLLINATION*

BY
A. H. HENDRICKSON

During the past three years the Division of Pomology of the University of California, and the Horticultural Commissioner of Santa Clara County have been conducting a number of experiments in an attempt to solve some of the problems connected with the pollination of plums and prunes. A part of this work was done at the University Farm at Davis and a part in the Santa Clara Valley. These experiments were undertaken to endeavor to find out why some plums bore abundant crops under certain conditions, while the same varieties under different conditions were either sterile or produced light crops. The question of what effect the interplanting of certain varieties had upon the size of the resulting crops also seemed to be of utmost importance, especially in view of the repeated inquiries concerning this factor which have been received at this office.

As a result of these investigations, the Division of Pomology has accumulated a mass of data which may help to elucidate some of the problems now confronting the plum and prune growers of this state. Among the most interesting results obtained during the season of 1916 were those relating to the common honey bee as a pollen-carrying agent. The experiment demonstrated to all who saw it that the honey bee is one of the most important agencies in transferring pollen from tree to tree.

In the Santa Clara Valley, where this part of the experiment was carried on, there are a large number of orchards of mixed varieties. Wherever the French prune is planted next to either the Sugar or Imperial prunes, there seemed to be a difference of opinion as to whether or not the size of the crop was in any way affected by the

* The following bulletin is a report on part of the pollination project which has been carried on by the University of California for the past three years. It is presented with the idea of bringing before the prune growers of the state the importance of the common honey bee as a factor, not to be overlooked, in the problems involved in prune pollination. Other reports will be presented from time to time as data warrant.

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SUMMARY

1. Sudan grass was obtained by the United States Department of Agriculture from Sudan, Egypt, 1909.
2. It is closely related to the cultivated sorghums and like them is an annual.
3. In general appearance it resembles Johnson grass but lacks entirely the underground rootstocks that make Johnson grass a pest.
4. Two or three cuttings of hay can be obtained from it under favorable conditions.
5. The yield varies from one to eight tons of cured hay per acre, dependent on the length of the frostless season, the temperature, altitude, soil and amount of available moisture, either by natural precipitation or by irrigation.
6. It will grow in a wide range of soils from sand to clay, but prefers a rich, well-drained, sandy loam.
7. The seed may be sown broadcast, drilled or in cultivated rows after all danger from frost is past, and the soil has become thoroughly warm.
8. It has been grown to a greater or less extent in almost every county of the state.
9. After seeding it takes from 75 to 80 days to secure the first cutting, about 45 days more for the second cutting, and 50 days more for the third.
10. The hay is palatable to all classes of stock as it is sweet like the sweet sorghums.
11. It is probably as nutritious as the grass and cereal hays, but cannot compete with alfalfa in this respect.
12. A seed crop can be produced in from 95 to 100 days with an average yield of between 600 and 800 pounds per acre.
13. Sudan grass is not an ideal pasture plant as in light soils the plants are apt to be pulled while being grazed.
14. As in the case of the sorghums, prussic acid (hydrocyanic acid) may develop in the leaves under unfavorable conditions and cause stock poisoning. Up to the present time, however, little trouble of this nature has been reported, although Sudan grass has been pastured to a considerable extent.
15. Sudan grass is good to look at, easy to grow and handle, grows during the summer, gives large yields, and is well liked by stock.

INTRODUCTION

Sudan grass is one of the most important forage crops introduced into the United States in the last twenty years. Its introduction dates back to 1909, when C. V. Piper, in charge of forage crop investigations for the United States Department of Agriculture, secured a half pound of seed from R. Hewison, Director of Agriculture, Khartum, Egypt. It is cultivated there under the name of "garawi" and is probably a native of northern Africa. Piper says that there are strong reasons for believing this plant to be the wild original form of the cultivated sorghums with which it readily crosses wherever

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the two are planted near each other. We have had sent to us a number of plants secured from seed of Sudan grass grown in close proximity to shallu, sometimes known as Arabian corn or Egyptian wheat, one of the sorghums. The plants had crossed one with the other so that nine distinct types could be recognized. In general appearance Sudan grass and Johnson grass resemble each other very closely, but the former is an annual and easily eradicated, while the latter is a perennial with underground rootstocks which are extremely difficult to kill by ordinary cultivation. Any portion of these rootstocks when separated from the parent plant, even if only an inch or so in length, is capable of producing new plants. They are also quite succulent and lose their moisture very slowly so that it is difficult to kill them even by exposure to drouth.

The leafage of Sudan grass and Johnson grass looks practically the some. Sudan grass in poor soil with insufficient moisture will rarely exceed three feet in height, while under ordinary conditions it averages five feet, or with very favorable conditions as high as ten feet. When sown thickly the stems are usually short and fine, about as thick as a lead pencil, but if grown in rows and cultivated, are taller with thicker stems.

The flowering parts are in the form of a loose panicle, or head, at the ends of the stems and closely resemble Johnson grass. The hulls are awned and often purplish in color. Commercial seed rarely has any awns as they are broken off in threshing. As many as one hundred stems may be produced from a single plant, but twenty-five is the usual number. The stems are quite leafy and remain firmly attached, both good points in a hay plant. Although the stems are coarse, this seems to be no objection as stock eat them quite readily.

Sudan grass is a heavy feeder, as would be expected from the large tonnage secured in a season. For this reason it would not be advisable even on rich soils to attempt to grow it on the same soil in two succeeding years. Unlike legumes, it is dependent solely on the soil for its source of nitrogen. Wherever possible it should be rotated with a leguminous crop, such as Canada field peas, with irrigation in the counties with cold winters; vetches, lima beans, common beans or horse beans in the coastal region of mild winters, and cowpeas, soy beans or garbanzos, as a summer crop in the southern interior counties where irrigation can be practiced.

The ideal way to grow Sudan grass would be with a legume as a mixture. This would have a tendency to maintain the fertility of the soil and to increase the protein content of the hay, making a well-balanced mixture of exceptional feeding value. On lands not subject

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to irrigation there are not many suitable legumes that have the same drouth-resistant qualities to enable them to be grown as summer crops. The two most likely ones are the chick pea or garbanzo (*Cicer arietinum*) and the tepary bean.

With irrigation, cowpeas or soy beans have been grown successfully with both Sudan grass and the sorghums. The black-eye bean, which is a cowpea, can be grown in many of the warmer coast and interior valleys of California and would be the most likely to succeed in conjunction with Sudan grass as a mixture under irrigation.

ADAPTATION

Climatic Requirements.—Sudan grass is adapted to the same general climatic conditions as the other members of the sorghum family. It seems to prefer a warm climate of relatively low humidity and like the other sorghums it is very susceptible to frost so that its growing season is limited to the warmer months of the year. From observations made in various sections of the state, the conditions in California as a whole appear to be favorable to its growth. Good results have been obtained with the crop, not only in the large interior valleys, but also in the valleys adjacent to the coast as well as in the smaller mountainous valleys located at elevations of from three thousand to four thousand feet. There are certain locations in the mountain valleys that are not subject to killing frosts owing to air currents which cause atmospheric drainage, while in the immediate vicinitiy lands not so situated may be subject to frosts every month during the spring and summer. This accounts for the apparent contradiction in the ability of Sudan grass to succeed in some of the northern counties. In some instances good crops are produced, while in others it is a complete failure. Apparently, however, it does not do as well on the agricultural lands subject to the cold, damp ocean breezes, as in the more protected valleys of the interior. While conclusive information is lacking, it is just probable, judging from results obtained in other states, that the plant is but poorly adapted to altitudes above five thousand feet.

In the interior valleys, where the growing season is from six to seven months in length, three and occasionally four cuttings of hay can be obtained. The first cutting requires from sixty to eighty days to mature, depending upon the season and soil conditions and upon the time of planting, while the later cuttings reach maturity in from forty-five to fifty-five days.

In the mountain valleys or at high elevations, the growing season is usually relatively short so that ordinarily only one or two cuttings

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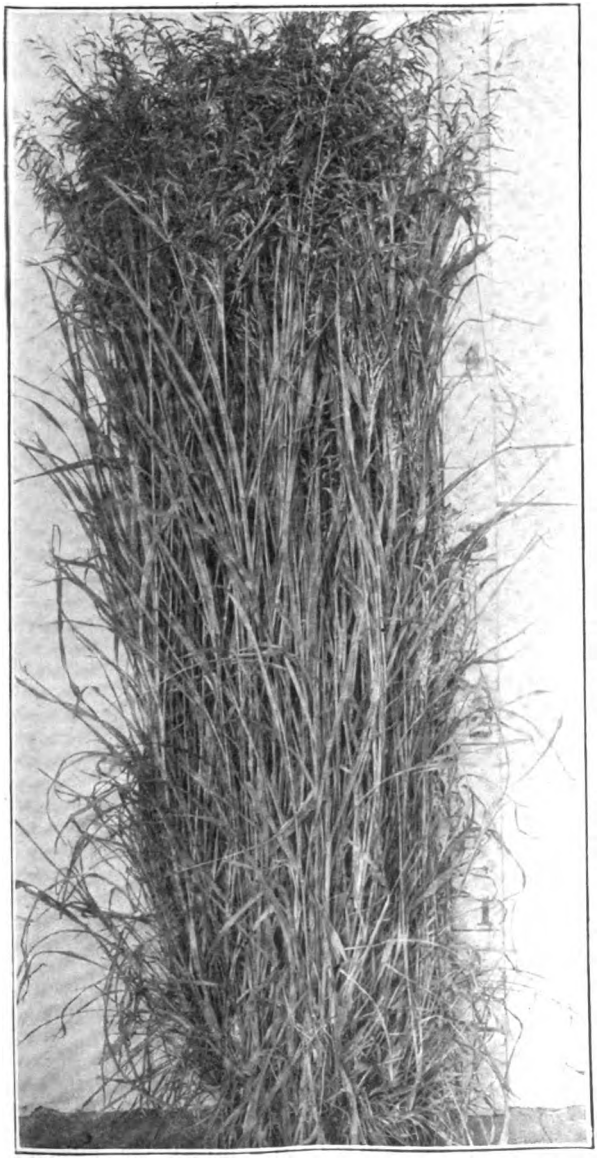

Fig. 1.—A single plant of Sudan grass produces many stems. They are leafy throughout their entire length.

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of hay will be obtained. Obviously the total yield per season will not be as large as in the more favored sections.

Soil Requirements.—From the general observations made throughout the state, Sudan grass does not appear to be at all exacting in its soil requirements. Favorable results have been obtained with the crop in many sections representing a variety of soil types and conditions. Like the other sorghums, however, it does best on a rich, well-drained loam. Exceedingly heavy soils are apt to be cold and damp and of poor physical condition, necessitating somewhat later planting, and in many cases producing a rather stunted growth. On extremely sandy soil, the growth of the crop is usually somewhat lighter than on the more favorable soil types, probably due to low fertility, lack of moisture, or poor physical condition. On most soil types, however, the growth of Sudan grass will ordinarily compare quite favorably with that of almost any other forage crop grown under similar conditions. No actual tests have been made by this station to determine to what extent Sudan grass will succeed on soils containing alkali, nor do we find any records in the literature. We have every reason to believe, however, that as in the case of the sorghums small amounts of white alkali will not be injurious.

Drouth Resistance.—Perhaps the most important character of Sudan grass and the one which will be of greatest value in stimulating the use of the crop for hay purposes, is its resistance to drouth. This character is possessed to a marked degree by all members of the sorghum family, but is probably more pronounced in the Sudan grass than in any of the other types. This was strikingly illustrated by the performance of the crop on the University Farm at Davis in 1913, which was an exceedingly dry year, the total precipitation amounting to only 8.84 inches. The grass was seeded on land which had been cropped to cereals the previous season and under these conditions produced an average yield of 3554 pounds of hay to the acre. Regarding the ability of Sudan grass to continue growth throughout the drier portions of the season, it is worthy of note that under the conditions mentioned, the average yield of the first cutting was only 937 pounds of hay per acre, while the second cutting gave an average yield of 1834 pounds per acre. The yield of the third cutting was slightly less than that of the first. Apparently this plant has a remarkable ability to make use of the limited soil moisture after its shallow but extensive root system has become fully developed. In all probability there are but few localities in the state where the rainfall is insufficient to produce a fair growth. Sudan grass is in fact one of the few plants which will maintain growth throughout the

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season under arid conditions. Obviously, however, the yields obtained will normally be in direct ratio to the moisture available, so that, for the best results, rigid conservation of the moisture supply should be practiced.

The most critical period in the growth of the Sudan grass seems to be while the plants are quite small or during the seedling stage. If the supply of water at the time of seeding is insufficient for prompt germination, or for the maintenance of normal growth until the plants are well established, permanent injury will result. This was clearly shown by the failure of the crop on the unirrigated Agronomy experimental plots in 1916. In the absence of spring rains after the first of March the soil dried out rapidly so that the moisture supply to a depth of six to eight inches was inadequate for rapid germination when the crop was seeded in April. As a consequence most of the seed failed to germinate, while the few plants which did appear were weak and spindling and soon perished. On a few spots in the plots where the soil had retained its moisture better, a fair stand was obtained, and the growth throughout the season was apparently normal. This would seem to indicate that after the plants have become well established they are able to hold their own under trying conditions.

Sudan Grass as an Irrigated Crop.—To what extent Sudan grass may become of importance as an irrigated crop is still a question, as on good, well-drained soils it must compete with alfala. While yields may be obtained which will compare favorably with or even exceed those of alfalfa, the total feed value per unit area will usually be considerably lower. Furthermore, because of the beneficial effect of the alfalfa on the soil, it is much to be preferred in any rotation system. On the other hand, Sudan grass being an annual may often be employed with profit as an emergency forage crop, and yet not interfere seriously with the general farming scheme. Alfalfa is more of a permanent crop requiring at least a year to reach its maximum productivity and is, therefore, not so applicable to the short rotation. Again, when the supply of water is limited, Sudan grass will produce much larger yields than will alfalfa under the same conditions.

It frequently happens that alfalfa yields, due to over-pasturing or the encroachments of weeds, or other causes, have become too low to be profitable. In the preparation of the land for reseeding to alfalfa no better crop could be utilized than Sudan grass, as there would be little loss in tonnage, the land would be benefited by the change and the weeds discouraged, leaving a good seed bed for fall or spring seeding of alfalfa.

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There are large areas of land in California which could be utilized for alfalfa, but for the overflow from the rivers in winter and early spring. These lands are sufficiently drained by the time for seeding Sudan grass. In such localities large crops of hay can be produced.

During the season of 1913 and 1914, Sudan grass was grown at the University Farm both with and without irrigation. In 1913 the unirrigated plots gave an average yield of 1.8 tons of hay to the acre, while the irrigated plot yielded 3.9 tons per acre. In 1914 the average yield of the dry plots was six tons per acre, and of the irrigated plots 7.6 tons per acre. In neither case did the crop obtain the optimum amounts of water as only one light irrigation per cutting was applied. During the latter season the average yield of well established alfalfa was seven tons per acre, though this crop received considerably more water than did the Sudan grass.

CULTURE

Preparation of the Seed Bed.—The seeds of Sudan grass are rather small so that a well-prepared seed bed is necessary to insure prompt germination and a good stand. In most sections of California the best results will probably be obtained by plowing the land rather deep in the fall or early winter, and allowing it to lie in the rough state throughout the rainy season. In this condition, the absorption of the winter precipitation will be greatly facilitated, at the same time assuring a sufficient packing of the soil for a good seed bed.

If the field is reasonably free from weeds the seed bed may then be prepared with a disc and a harrow. If, however, the weed growth is rather heavy a shallow plowing early in the spring may be necessary before a good seed bed can be secured.

In some instances spring plowing has been recommended for crops of this character on the ground that the spring-plowed land warmed up somewhat more quickly, making earlier seeding possible. While definite information along this line is wanting, the fact that the soils in this state are subjected to rather cold rains during the month of March, makes this effect seem rather doubtful.

When the land has been plowed in the spring, as may sometimes be necessary, more labor is usually required to get the soil worked down into a good seed bed than when the land has been fall-plowed. since the rain falling upon the land at this season of the year is seldom sufficient to pack the soil properly. The bottom of the seed bed must be rather firm and compact in order to establish proper capillary connection with the soil beneath, as well as to provide a rather firm base on which to plant the seed. Only the surface two or three inches

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of soil should be loose and finely pulverized, which is sufficient to check evaporation and provide the necessary aeration for the germination of the seed.

Seeding Sudan Grass.—Sudan grass is a new crop in this country and differs materially from any of the better known crops in its adaptation and manner of growth. For this reason, no precedent is available to guide the grower as to the most efficient means of handling the crop except such general knowledge as might apply to the plant family as a whole. To secure definite information as to the best time, rate and method of seeding, both with and without irrigation, experiments were undertaken at Davis in 1913. While this work has been

Fig. 2.—Sudan grass grows so tall and thick that weeds have no chance to grow.

in progress but three years, some rather striking results have been obtained.

Time of Seeding.—Inasmuch as Sudan grass is a warm-weather plant it should not be seeded until all danger of frost is past or until the soil has become thoroughly warm. If the seed is planted in soil that is too cold the germination is apt to be low, resulting in a poor stand. Then, too, the cold soil or atmospheric conditions encountered by too early seeding may materially stunt the early growth of the plants from which they will be rather slow to recover. The best time of seeding, however, will necessarily vary with the location and to some extent with the type and character of the soil. The results of tests conducted at the University Farm at Davis during the past three seasons to determine the effect of time of seeding Sudan grass for hay production are given in Table I.

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TABLE I

DATE OF SEEDING

Date seeded	Yield of hay per acre, pounds							
	Dry				Irrigated			
	First cutting	Second cutting	Third cutting	Total for season	First cutting	Second cutting	Third cutting	Total for season
				1914				
Mar. 20	2,485.2	2,844.9	1,733.1	7,063.2	2,560	4,848	2,660	10,060
Apr. 15	6,114.9	2,943.0	2,844.9	11,902.8	7,080	4,400	3,440	14,920
May 1	1,275.3	3,646.0	.....	4,921.3	2,440	5,300	.....	7,740
May 15	2,861.2	4,888.6	.....	7,749.8	4,560	4,980	.....	9,540
June 1	1,635.0	2,011.0	.....	3,646.0	2,900	3,900	.....	6,800
				1915				
Mar. 17	3,561.6	6,025.0	4,569.8	14,156.3	.....	.....	.....	.....
Apr. 6	4,120.2	4,594.3	4,095.7	12,810.2	.....	.....	.....	.....
Apr. 20	4,169.2	5,320.1	2,681.4	12,170.7	.....	.....	.....	.....
May 3	6,556.3	5,559.0	1,765.8	13,881.1	.....	.....	.....	.....
May 18	6,425.5	5,714.3	.....	12,139.8	.....	.....	.....	.....
June 1	4,332.7	4,839.6	.....	9,172.3	.....	.....	.....	.....
				1916				
Mar. 17	.....	.....	.....	.....	540	5,000	6,950	12,490
Apr. 6	.....	.....	.....	.....	6,110	6,480	.....	12,590
Apr. 17	.....	.....	.....	.....	5,290	7,010	.....	12,300
May 1	.....	.....	.....	.....	5,820	5,910	.....	11,730
May 15	.....	.....	.....	.....	4,170	6,350	.....	10,520

On the whole, the highest yields were obtained from the April planting regardless of whether the plot was dry or irrigated. While in 1915 the highest yield was obtained from the earliest seeded plot, attention must be called to the fact that the season was quite favorable for growth during the latter part of March and the first of April, while the latter part of April to the middle of May was very cold and wet and on the whole unfavorable for growth.

Plantings made later than May 3 produced only two full cuttings of hay during the season as compared with three cuttings from the earlier seeded plots. While some growth was obtained after the second cutting, it failed to make enough growth for a hay crop before it was killed by the early fall frosts.

The low yield for 1914 from the plot seeded June 1 is due primarily to a poor stand. In 1915 better results were obtained as the soil contained more moisture at that date than the preceding year, due to the late spring rains. The stand, however, was not as good as that obtained on the earlier seedings. On the irrigated plot planted June 1, 1914, had the water been applied before seeding instead of after the plants were up, the stand as well as the yield would, in all prob-

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ability, have been greatly improved. In 1916 the soil was so dry the latter part of March that the stand obtained, even on the early seeded plot, was very poor. The later plantings were irrigated immediately after seeding and much better results were obtained.

While in this experiment the latest seeding was made June 1, it has been observed that when the land can be irrigated before seeding, good crops of hay may be obtained in some localities by seeding as late as the first of August. On the whole, however, where the land can not be irrigated and when the maximum yield of hay is desired, it is advisable to seed as early as soil and climatic conditions will permit. By seeding comparatively early, the root systems of the plants become thoroughly established while the moisture supply is still abundant, thus enabling them to make a better growth throughout the drier portion of the year.

Method of Seeding.—For hay purposes Sudan grass may be seeded either in cultivated rows or in close drills. The latter method will probably meet with the greatest favor, especially when the supply of moisture is fairly abundant, as practically no attention is necessary after the crop has been seeded. When put in in this way the ordinary grain drill may be used for seeding the crop as almost any good implement can be set to seed as low as twelve to fifteen pounds to the acre.

In the drier sections better results will often be obtained by seeding in cultivated rows eighteen inches or more apart. This method provides the individual plants with a greater area from which to receive sufficient moisture to enable them to develop normally, and at the same time permits of the necessary cultivation for the conservation of the moisture. A considerable saving of seed is also effected, which may be an important consideration when the price of the seed is high.

For planting the crop in rows the ordinary grain drill may be used by stopping up enough of the holes to give the proper spacing. Fair results have also been reported by using a corn planter provided with special plates for dropping the seed.

Experiments to determine the effect of various methods of seeding on the relative yield of hay have been conducted on the University Farm during the seasons of 1913, 1914, 1915, and 1916. The results obtained are given in Table II.

While the results given in this table show considerable variation and are not readily comparable, the yield on the dry plots, for the past two seasons at least, was decidedly in favor of the eighteen-inch rows. In 1913, which was an exceedingly dry season, the difference in

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TABLE II

METHOD OF SEEDING

Method for seeding	Yield of hay per acre, pounds: Dry — First cutting	Second cutting	Third cutting	Total for season	Irrigated — First cutting	Second cutting	Third cutting	Total for season
Drilled, 24 lbs.			1913					
per acre....	1,780	2,320	1,040	5,140*	4,710	2,380	1,920	9,010
18-inch rows	840	2,000	880	3,720	4,040	2,940	1,600	8,580
44-inch rows	1,100	1,840	800	3,740	1,460	4,680	880	7,020
* Received a partial irrigation early in the season by mistake.								
Drilled, 20 lbs.			1914					
per acre....	4,578.0	3,213.6	2,436.1	10,227.7	7,520	3,600	3,740	14,860
18-inch rows	7,390.2	4,202.0	2,812.2	14,404.4	6,600	6,600	4,820	18,020
36-inch rows	4,490.2	2,335.4	2,926.6	10,709.2	4,560	6,240	7,300	18,100
Drilled, 25 lbs.			1915					
per acre....	3,016.6	3,482.5	1,986.5	8,485.6	.....	.....	.....	.....
18-inch rows	3,008.4	3,964.9	1,765.8	8,739.1	.....	.....	.....	.....
36-inch rows	2,321.7	3,474.4	1,888.4	7,684.5	.....	.....	.....	.....
Drilled, 20 lbs.			1916					
per acre....	.....	.....	.....	.....	4,800	8,210	.....	13,010
18-inch rows	.....	.....	.....	.....	5,060	7,280	.....	12,340
36-inch rows	.....	.....	.....	.....	2,820	6,460	.....	9,280

yield between the eighteen-inch rows and the forty-four-inch rows was very slight. This would seem to indicate that when the supply of moisture is fairly abundant the highest production could be obtained by planting in rather narrow rows, while under drier conditions, at least equally as good yields would be obtained from the wider rows.

On the irrigated plots it is of interest to note that in 1913 and 1916 the yield decreased from the drill plots to the thirty-six and forty-four-inch row plots, while in 1914, both the row plantings decidedly outyielded the drill plot. During this latter season, however, the difference between the two row-plantings was too slight to be significant. It is quite probable that further experience will show that when the crop can be properly irrigated, the method of planting will have far less effect upon the yield than when it is grown as a dry land crop.

It has been stated that in some sections the hay produced from row plantings was somewhat coarser in quality than that grown in close drills. In the experiments at Davis, the difference in this respect was not as great as might have been expected, especially where the conditions for growth on the close-drilled plats were good. In

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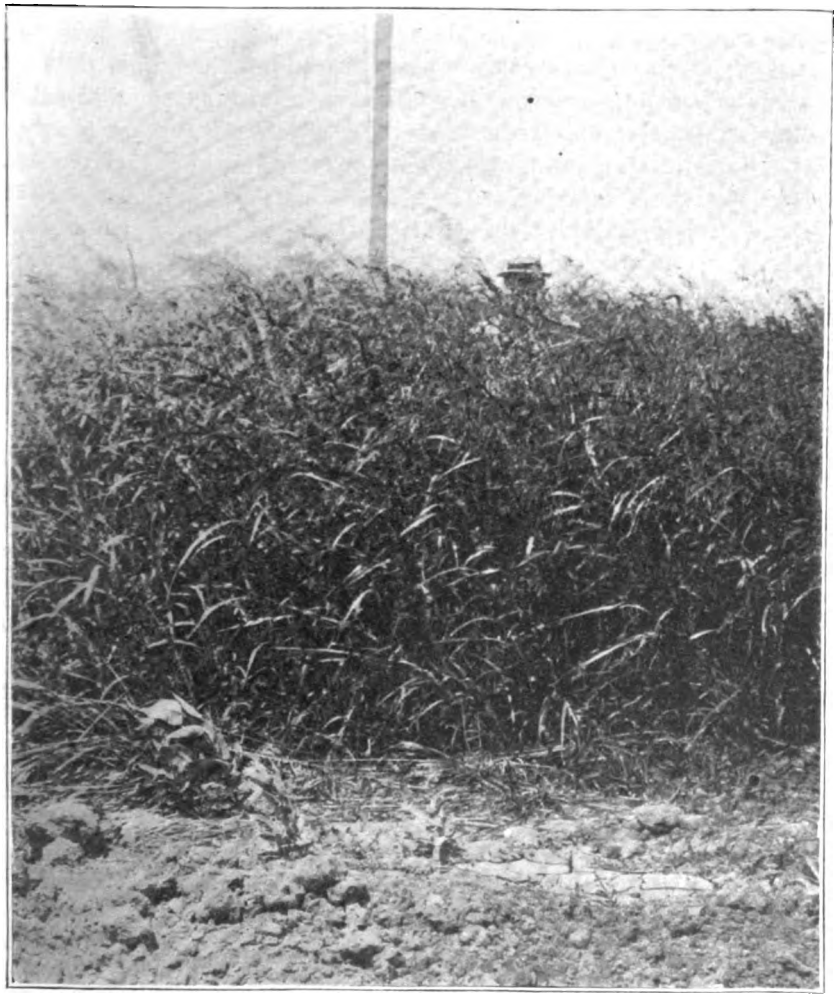

Fig. 3.—Under irrigation Sudan grass produces a rank growth. If cut at the proper time the hay is tender and palatable.

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all cases, however, the plants stooled much more in the rows than in the close drills.

Rate of Seeding.—The proper rate of seeding Sudan grass will doubtless vary somewhat with the local soil and climatic conditions. It does not appear, however, that the rate of seeding bears as direct a relation to the moisture supply as does the method of seeding. Because of the free stooling character of the plant, the actual yield will be less affected by the rate of seeding than with most other annual crops. However, the excessive stooling which takes place when the stand is thin, may lower the quality of the hay owing to the wide range in time of maturity of the various parts of the plant. If the crop is harvested when the main portion of the plant is at the proper stage, many of the later suckers will be quite immature, while if harvesting is delayed until all suckers are fully headed, the central stem will become coarse and less palatable.

TABLE III

RATE OF SEEDING

Rate seeded per acre, pounds	Yield of hay per acre, pounds							
	Dry				Irrigated			
	First cutting	Second cutting	Third cutting	Total for season	First cutting	Second cutting	Third cutting	Total for season
1913								
15	780	1,680	660	3,160	2,870	3,110	1,040	7,020
20	630	1,530	480	2,640	2,960	3,630	1,080	7,670
30	780	1,820	720	3,320	.....	.....	.....	.....
40	650	1,650	900	3,200	.....	.....	.....	.....
1914								
10	5,460.9	4,937.7	3,580.6	13,979.2	5,640	8,540	5,000	19,180
15	6,180.3	4,643.4	3,041.0	13,864.8	6,480	6,100	2,820	15,400
20	6,180.3	3,335.4	2,828.5	12,344.2	6,680	4,320	2,960	13,760
25	5,657.1	3,417.1	2,583.3	11,657.5	4,800	4,560	2,960	12,320
35	6,861.0	4,447.2	2,926.6	14,240.8	7,320	5,020	4,160	15,500
1915								
10	4,251.0	6,360.1	4,684.3	15,295.4	.....	.....	.....	.....
15	4,406.3	5,951.4	4,177.4	14,535.1	.....	.....	.....	.....
20	4,240.9	5,215.6	3,932.2	13,388.7	.....	.....	.....	.....
25	4,937.7	4,005.7	1,847.6	10,791.0	.....	.....	.....	.....
35	4,136.5	4,316.4	1,602.3	10,055.2	.....	.....	.....	.....
1916								
10	.....	.....	.....	.....	5,140	7,770	.....	12,910
15	.....	.....	.....	.....	5,820	5,740	.....	11,560
20	.....	.....	.....	.....	6,570	8,790	.....	15,360
25	.....	.....	.....	.....	5,380	5,880	.....	11,260
35	.....	.....	.....	.....	4,340	4,810	.....	9,150

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Results of tests conducted at Davis during the seasons of 1913–1916, inclusive, to determine the effect of various rates of seeding on the yield of hay are given in Table III.

The results for the four years taken as a whole are quite variable. In 1913, the highest yield was obtained by seeding thirty pounds per acre, while the next higher yield was obtained when the rate of seeding was forty pounds. In 1914, the yield decreased with an increase in the rate of seeding from ten to twenty-five pounds per acre both under dry culture and with irrigation. On the dry plats the thirty-five-pound seeding produced the highest total yield, though the difference between the yield on this plat and the one seeded at the rate of ten pounds per acre was not sufficient to warrant the use of the larger amount of seed. In 1915, the total yield decreased very rapidly with an increase in the rate of seeding. In 1916, on the other hand, seeding at the rate of twenty pounds per acre gave the best results, with the ten-pound seeding second. In the remaining cases the yield decreased with an increase in the amount of seed used. Apparently the most productive seeding rate where the crop is seeded in close drills and the conditions for growth are good is from ten to fifteen pounds per acre.

Cultivation.—When Sudan grass has been seeded in close drills, cultivation will seldom be necessary after the crop has been seeded, though if the soil becomes encrusted before the plants appear, or while they are still quite young, a light harrowing may be desirable. On the other hand, when the crop is seeded in rows, some cultivation will be necessary, primarily to maintain the surface mulch and check evaporation. Weed growth will seldom be a serious menace to Sudan grass, as the crop grows with such rapidity and vigor as to keep the weeds in check quite efficiently. It is only when seeded extremely early, in which case the growth is apt to be rather slow, or when seeded on very foul soil, that the weed growth will be likely to be injurious.

Two cultivations during the growth of the first crop and one cultivation after each cutting, or after each irrigation, will usually be sufficient. The first cultivation should be rather deep and should be given as soon as the plants are large enough so that the rows can be followed easily. Later cultivation should be more shallow in order not to injure the surface roots of the plants.

The most effective implement to use will depend somewhat upon the distance between the rows. When the rows are twenty-four inches or more apart, the ordinary two-horse corn cultivator may be used, though an implement with rather small shovels is to be preferred as

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the small shovels have a greater pulverizing effect on the soil and leave a smooth surface. When the rows are less than twenty-four inches apart a one-horse cultivator of the type used for cultivating truck crops will probably be the most efficient.

Irrigation.—While Sudan grass will doubtless be used most extensively as a dry land crop, there is no question but that as a forage crop it will be employed to some extent under irrigation, either as a supplement to alfalfa hay or as a second crop to follow a spring-grown crop. Again, in sections where the precipitation is low and the supply of irrigation water is limited, much larger yields of forage will often be obtained by applying the small amount of water available to Sudan grass rather than to alfalfa. While no definite data are available on the amount of water necessary for a maximum crop, the best results will probably not be obtained with less than twenty-five inches, including the natural precipitation.

When Sudan grass is planted early in the spring, it will seldom be necessary to irrigate the ground before seeding, as the natural moisture will usually be sufficient to germinate the seed and start the plants. Ordinarily three or four irrigations throughout the growing season will be sufficient under most conditions. The first irrigation should be applied when the first growth is from eighteen to twenty-five inches in height or just before heading. The later irrigations may be applied after each cutting or as soon as the new growth has started. On light soil it will doubtless be better to give two light applications of water per cutting than one heavy application.

When Sudan grass is to be grown following a spring crop, such as grain, irrigation of the field will be necessary before the seed bed for the grass can be prepared. If a rather heavy application of water is given at this time, further irrigations will not be necessary until the first cutting is nearly mature. The flooding method of irrigation is to be preferred with Sudan grass even when seeded in rows, as furrowing between the rows might severely injure the extensive surface root system of the plants. With proper checking and leveling of the field before seeding no great difficulty should be experienced in securing a uniform distribution of the water.

SUDAN GRASS IN THE ROTATION

Inasmuch as Sudan grass is an annual crop, it can be worked into almost any rotation in much the same manner as sorghums, corn or other annuals of that character. Under dry farming it can be employed in the cereal rotation with profit to replace grain hay, since it is more drouth-resistant and much more productive as a hay crop

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than any of the cereals. Being a sorghum, however, and a rank grower, it draws heavily upon the moisture and fertility of the soil and leaves but little in the soil for improvement except the decayed roots. It is quite probable that crops susceptible to effects of plants of this character, such as barley, should not be put upon the land immediately following Sudan grass.

It is also apparent that the best results will not be obtained with Sudan grass if it is put upon land used for Sudan grass the previous season. In 1915, the yield obtained on land which had been cropped to Sudan grass the previous season was only 4.24 tons of hay per acre, whereas the yield on land upon which a cultivated crop had been grown the previous season yielded 6.69 tons per acre. Both plots were seeded at the same time and at the same rate, and otherwise handled in identically the same manner. The fact that the crop can be seeded late and still produce large yields of forage will doubtless render it of great value as a second crop under irrigation. It can be employed in this way to follow a spring crop, such as grain or spring pasture or, in fact, any crop which could be removed from the land by the first to the middle of July.

THE HAY CROP

Time of Cutting.—In order to secure the highest quality of hay, Sudan grass should be cut when in full bloom. If harvesting is delayed until the seed is ripe, the hay will be a little coarse and a little less palatable than if cut earlier. The decrease in feeding value on maturity is probably not as great in Sudan grass as with some other crops, since in common with many of the other sorghums the stems and leaves remain green until after the seed is ripe. In addition to this fact, the plants stool extensively so that the later suckers will be quite immature even when the main stems of the plant are ripe. On the other hand, if the crop is cut before heading, the feeding value of the product is apt to be quite low though its palatability may not be impaired.

Method of Harvesting.—The most common way of harvesting the hay crop is with a mower. It is subsequently handled in much the same manner as millets and other coarse grasses. During the bright, warm days of the summer, grass cut one morning will usually be ready to rake into windrows or bunches the next day. To produce a bright hay of high quality, it should be put into cocks and allowed to cure for three or four days before being put into the mow or stack. While the leaves cure quite readily, the large juicy stems retain their moisture somewhat longer so that hay which appears to be well cured may

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still contain a relatively high percentage of moisture. At Davis, hay cut in July, 1915, contained from 25 to 35 per cent of moisture after curing in the swath and windrows for three days. A few days of additional curing in the cock, however, reduced the moisture content to 20 per cent or less.

In some instances the grain binder has been used for harvesting the hay crop, the bundles being set into shocks to cure. While this method facilitates handling somewhat, it is not likely to become very popular owing to the difficulties encountered in harvesting a heavy crop. When the grass has been planted in rows, harvesting may be done with the row or corn binder. As neither of these implements is commonly found on the farms in California, the mower will doubtless be the most popular means of harvesting, the hay then being handled as any other hay crop.

Yield of Hay.—The yields of hay which may be obtained with Sudan grass will vary somewhat with the conditions of the soil, the supply of moisture and the other factors which enhance or retard plant growth, though the first two factors will doubtless be of the greatest importance.

During the three years in which Sudan grass has been grown at Davis, the yields of cured hay have varied from 1.32 tons to 9.59 tons per acre, on the individual plots. Considering the average yields obtained on the different plots for dry and irrigated land each season, the results have been as follows:

TABLE IV

YIELD OF SUDAN GRASS HAY

	Dry, tons per acre	Irrigated, tons per acre
1913	1.78	3.93
1914	5.26	6.74
1915	5.86	.....
1916	.....	5.94

The results here given include the average of all dry and all irrigated plantings regardless of the time, rate or method of seeding. Naturally, plantings made rather late, producing only two cuttings, will not, as a rule, give as high yields as earlier plantings. Furthermore, it is quite likely that the application of more water, or at least applications at more frequent intervals, would have increased the yields under irrigation materially. In these experiments only one light application per cutting was given, which may not have been enough for the maximum growth.

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FEEDING VALUE OF SUDAN GRASS HAY

The feeding value of a product depends not only upon its composition and digestibility, but to a large extent upon its palatability to the animals which consume it. While no feeding tests have as yet been conducted with Sudan grass hay, observations indicate that it is relished by all classes of hay-eating animals, nor does it appear to have any deleterious effect on the digestive system. Instances have been brought to our attention where farm stock with long hours of heavy work have kept in good condition on Sudan grass hay without a grain ration.

Fig. 4.—The mower is well adapted to harvesting Sudan grass for hay.

The palatability of the product is doubtless enhanced by the juciness and sweetness of the plants, as it has been observed that even though the hay is rather coarse, but little waste occurs when it is fed.

Regarding the composition of the hay, claims have frequently been made that it compared favorably with alfalfa hay. These claims, however, have usually been advanced by parties having Sudan grass seed for sale. Analyses made of the hay grown at the University Farm in 1915 in comparison with some of the more common hay crops are given in Table V.

The data in this table clearly show that Sudan grass compares in composition more nearly with the other grass hays than with alfalfa. It is a little lower in protein than either barley hay or rye grass hay,

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TABLE V

AVERAGE COMPOSITION OF VARIOUS HAY CROPS—WATER-FREE BASIS*

Kind of hay	Protein	Fat	Crude fiber	Nitrogen free extract	Ash
Sudan grass	6.9	3.0	27.9	55.0	7.2
Barley hay	10.3	2.8	29.0	53.0	4.9
Rye grass	10.5	3.5	27.5	49.3	9.2
Timothy	6.8	2.9	33.4	51.9	5.0
Alfalfa	16.8	2.3	30.1	42.0	8.8

* Analyses supplied by Professor Woll.

and about the same in fat and crude fiber. Its ash content is considerably higher than that of barley hay, and only slightly lower than that of rye grass hay. In comparison with timothy its protein and fat content are approximately the same, but it is considerably higher in carbohydrates and ash. The hay from which the above analyses were made was cut when in full bloom, which is the usual time recommended for harvesting crops of this character, though it may not necessarily give a product of the highest nutritive value.

When the nutritive value per unit of area is considered, Sudan grass is superior to any of the other grain hays because of its higher yield. The average yield of Sudan grass hay from all non-irrigated tests during the first three years has been 8640 pounds per acre. Under similar conditions 4000 pounds per acre is considered a good yield for either barley, rye grass or timothy hay.

In Table VI is shown the feeding value per acre of the grass hays given in the previous table, based on composition.

TABLE VI

YIELD OF CONSTITUENTS IN POUNDS PER ACRE FROM GRASS HAYS

Kind of hay	Yield per acre	Dry matter	Protein	Fat	Crude fiber	Nitrogen free extract	Ash
Sudan grass	8,640	6,367.7	439.4	191.0	1,794.6	3,485.2	457.5
Barley hay	4,000	3,400.0	350.2	95.2	996.0	1,792.0	166.6
Rye grass	4,000	3,520.0	369.6	123.2	968.0	1,735.5	323.8
Timothy	4,000	3,316.0	225.5	96.2	1,107.5	1,721.0	165.8

It will be noted that the acre yield of protein in the Sudan grass is about twice as great as that of timothy hay, and at least a fourth more than rye grass or barley hay. In the case of fat and ash the acre yield of Sudan grass is more than twice as great as for either barley or timothy and more than a third greater than rye grass, while its yield of carbohydrates is double that of the other grasses. While the value of Sudan grass hay, per unit of weight, is no greater than that of the other grass hays, the larger yields per acre and the

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fact that it can be grown under conditions wholly unsuited to the other types will doubtless make it of inestimable value to the stock growers of the state.

SUDAN GRASS PASTURE

As yet but little definite information is available as to the value of Sudan grass for pasture, though from the character of the plant it would seem to lack some of the necessary properties of a good pasture crop. In the first place being an annual, considerable time would be required for the root system to develop sufficiently so that the plant would not be pulled out by grazing animals. Again, since the soil in which the seed is planted is naturally quite soft, the young plants would probably be severely injured if pastured too early. If the plants were allowed to attain some size before the stock is turned in but little injury would be likely to result. Another possible objection to Sudan grass as a pasture plant is that being a sorghum, it may, if subjected to extreme drouth, to too heavy grazing, or other unfavorable conditions, develop prussic acid (hydrocyanic), which is quickly fatal to stock.

The fact that the grass will maintain rather rapid growth throughout the drier portion of the year, however, is strongly in its favor. This ability is possessed by but few plants which could be used for pasture purposes. The danger from poisoning by members of the sorghum family has, on the whole, doubtless been over-estimated, as the death rate among live stock from this source is very low as compared with other causes.

In order to secure some information on the value of Sudan grass as a pasture crop, a pasturing experiment was begun in 1916 in cooperation with the Division of Animal Industry. While the results obtained were not wholly satisfactory, the ability of the crop to withstand rather heavy pasturing after the plants were well-established was amply demonstrated.

A two-acre field of silt loam was chosen for the experiment. Because of the dry spring it was necessary to irrigate the land before seeding. As soon as the soil was dry enough to work properly the seed bed was prepared and the crop seeded at the rate of twenty pounds per acre on June 17. The seed germinated quickly and a good stand was obtained over practically the whole tract. Since it was feared that the plants would be pulled up or otherwise injured if the stock was turned on while the plants were small, pasturing was not begun until July 24, at which time the plants had attained a height of about two feet. On this date thirty-five lambs were turned

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into the field, and while they seemed to relish the feed highly, they made practically no reduction in the growth. Three days later eleven ewes were added to the flock, but even this heavy pasturing did not affect the growth of the crop. The Sudan grass headed about the first of August and on the 3rd the sheep were removed and the crop cut for hay, 4.65 tons of cured hay being removed from the two acres. Two weeks were allowed after cutting for the plants to recuperate before being again pastured. From this time until September 26 the field was pastured intermittently; on the latter date fifteen sheep were again put upon the field where they remained until October 29, a week after the growth was killed by frost. All the sheep made gains of about one-third of a pound per day throughout the period they were on pasture, and at no time was any injurious effect noted. Had the field been seeded earlier and had the proper stage of growth, as well as the carrying capacity of the field been better understood, a much longer period of pasturing would doubtless have been obtained.

Many reports have been obtained praising Sudan grass as a summer pasture for all classes of livestock, but the only exact data that have come to the writers' attention were submitted by Mr. F. F. Lyons, while Farm Adviser of San Joaquin County, citing the experience of a farmer in that section in 1915. The field in question was ten acres in size, the crop being planted in rows three feet apart, primarily for seed production purposes. The seed crop was cut the second week in July, yielding six hundred pounds of seed per acre. As soon as the new growth started, seven cows and five horses were turned in and maintained continually until the crop was killed by frost in November. The horses received some hay in addition to the pasture, but the cows received no other feed throughout the whole period. These results are indeed remarkable considering the manner in which the crop had been planted. If they may be taken as an indication of what can be expected of the plant for pasture, the future of the crop for this purpose is certainly bright, since in this instance at least, it equalled in carrying capacity a good stand of alfalfa.

SEED PRODUCTION

Up to the present time Sudan grass has been grown primarily as a seed crop, owing largely to the high price which this produce commanded. While these high prices can not continue, there will always be a considerable demand for seed, since the crop is an annual and must be seeded every year. The production of seed, therefore, will doubtless continue to be a profitable industry, especially in those sections where a good quality of clean seed can be grown.

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Fig. 5.—In experimental plantings Sudan grass is tall and vigorous in growth. When in bloom it is ready to harvest.

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The seed habits of Sudan grass are excellent. It is produced in large open panicles ten to fourteen inches in length, borne fairly high, upon erect stalks making the harvesting of the crop relatively easy. The seed is retained quite well so that under most conditions, but little loss from shattering will result. If, however, the crop is subjected to strong winds, when the seed is mature, a considerable portion of it may be lost by shattering.

The first crop of seed requires from ninety-five to one hundred days to mature under normal conditions. After cutting, the plants recover very quickly so that under favorable conditions when the growing season is of sufficient length a second crop of seed may be produced. This second crop, however, usually requires from one hundred and ten to one hundred and twenty days to mature, so there is always the danger of its being injured by frost before it is ripe. Furthermore, neither the yield nor the quality of the seed from the second cutting will be as good as from the first.

In most cases it will doubtless be more economical to utilize the growth after the seed crop either for hay or for pasture, or else to harvest the first crop of the season for hay, allowing the second to mature seed. In this latter case a seed crop could be matured in most sections of the state without the danger of injury by frost.

In growing a seed crop, however, care should be taken to see that it is grown on land that is absolutely free from Johnson grass, as the seed of these two plants are so nearly alike as to be distinguished only with great difficulty. In producing seed, farmers should aim to secure their supply from sections free from Johnson grass in order to avoid the danger of introducing this pest. In sections where Johnson grass is not present, it will probably be advisable for the farmer to grow his own seed, since ordinarily only a small area will be required to produce the desired amount. In sections favorable for the production of seed, good returns may be obtained from the seed crop even though the price drops as low as five or six cents as at present indicated.

Preparation of Soil.—As yet but little definite information is available as to the best means of handling the seed crop. The experiments conducted thus far have referred primarily to the method of seeding for maximum seed production and not to the other cultural practices. In the preparation of the seed bed, however, the same general cultural methods should be followed as in the production of a forage crop. It should be mellow and well prepared in order to secure a uniform stand of healthy plants.

Time of Seeding.—Early planting or as soon as the soil is sufficiently warm to maintain normal growth will in most cases be pro-

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ductive of the best results. At this season of the year the supply of moisture is abundant and the plants will ordinarily make a better growth than if seeded later. On the other hand, if the land can be irrigated, later seeding may be practiced. It is probably never advisable, however, to plant a seed crop later than the first of July, since the season at the time of maturity will be too cool for the best development.

Method of Seeding.—For seed production Sudan grass may be planted either in close drills or in rows, in the same manner as described in the discussion on forage. Owing to the scarcity of seed during the past two or three years, most of the planting for seed production has been in cultivated rows, in order to secure as large yields as possible, by forcing the plants to stool extensively.

Results of tests conducted at Davis during the season 1913 to 1915 to determine the value of different methods of seeding on the relative yield of hay are given in Table VII.

TABLE VII

SEED PRODUCTION, METHOD OF SEEDING

Method of seeding	Yield of seed per acre, pounds 1913 1st cut.	1913 2nd cut.	1913 Total for season	1914 1st cut.	1914 2nd cut.	1914 Total for season	1915 One cut. only	1916 One cut. only
Dry—								
36-inch rows	65	30	95	1,308	408.7	1,716.5	621.3	.....
18-inch rows	50	60	110	1,340	490.5	1,830.5	1,013.7	.....
20 lbs. drilled	150	35	185	1,303	457.8	1,765.8	964.6	.....
30 lbs. drilled	120	30	150	.....	.....	.....	.....	.....
Irrigated—								
36-inch rows	880	270	1,150	800	340	1,140	.....	740
18-inch rows	400	180	580	1,540	490	2,030	.....	940
20 lbs. drilled	280	30	310	1,240	530	1,760	.....	1,760
30 lbs. drilled	680	30	710*	.....	.....	.....	.....	.....

* Average of two plots.

The results given in this table for the seasons 1914 and 1915, at least, favor planting in eighteen-inch rows. In 1914, however, the difference when no irrigation was given is not as great as with irrigation. In 1916, on the other hand, when the crop was grown with irrigation much the best results were obtained from the close-drilled plots. The results for 1913 were, on the whole, extremely variable. One would naturally expect, with the light rainfall which obtained that season, that the thirty-six-inch rows would have given the highest yield. This expectation, however, was upset largely by the poor stand obtained.

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Further trials under similar conditions will be necessary to verify these results.

Rate of Seeding.—Unfortunately no definite information is yet available on the rate of seeding for the maximum seed production. It has been stated that if a light rate of seeding was used, the strong tendencies to stool profusely would cause uneven ripening and therefore, a poor, immature quality of seed. This same objection might be raised with regard to growing the crop in cultivated rows. However, thus far the results obtained at Davis have not borne out this contention. When seeded in close drills the maximum yields will probably be obtained if seeded at the rate of from fifteen to twenty pounds per acre under most conditions. When seeded in cultivated rows the amount of seed required will vary with the distance between the rows, usually from four to seven pounds per acre.

Harvesting the Seed Crop.—The seed crop should be cut when the majority of the heads on the main portion of the plant are ripe. It is seldom wise to allow it to stand until all the heads on the later shoots are mature, for while it does not shatter easily, if subjected to the hard winds prevalent in many of the valleys of the state, a considerable loss is bound to occur. Furthermore, the plumpest seed is produced on the main heads and it is this portion that would be lost if shattering occurred. On the other hand, if the crop is cut too early, the seed will be light and chaffy, with the result that a considerable portion of it will be screened or blown out in the threshing and cleaning process. For harvesting the seed crop the ordinary grain binder is the most economical as well as the most efficient. The bundles can then be set into shocks to cure, where they should remain for a period of from ten days to two weeks. If desired, the bundles may be stacked like other grain, but this is seldom necessary in a dry climate such as prevails in California.

Harvesting may also be done with a mower, cutting and handling the crop like hay. This method, however, is not to be recommended as a considerable quantity of seed will be lost in the process of handling.

Threshing.—Sudan grass may be threshed with the ordinary grain separator. The only change necessary will be the reduction of the air blast from the fan to prevent the seed from being blown over with the chaff. If the cylinder is run at a high rate of speed, or if several rows of concaves are used, the coverings will be removed from a large proportion of the seed. While the presence or absence of the hulls does not appear to affect the germination of the seed, it has a better appearance if the glumes are retained. For this reason no greater

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speed of the cylinder or no more concaves should be used than will be necessary to completely remove the seed from the heads.

Cleaning.—Even though most of the chaff and foreign material will be removed in threshing, it will usually be necessary to reclean the seed in order to secure a high-grade product. Any ordinary fanning mill fitted with proper screens will clean Sudan grass seed, though a machine possessing a vertical air blast will be found to be the most efficient for the removal of the chaff and light immature seed which can not be removed by the screen.

Yield of Seed.—The yield of seed will be quite variable, according to the character of the soil, the supply of moisture and the general seasonal condition for growth. During the past three years, the yields of seed at Davis have ranged from ninety-five pounds per acre to two thousand and thirty pounds per acre. The average yields for the four years are as follows:

Year	Dry	Irrigated
1913	135.0	687.5
1914	1,770.9	1,643.0
1915	866.5	.....
1916	.....	1,146.6

From these results it will be noted that there was a very wide difference in seed production in different seasons. The extremely low yield in 1913 was due to the combined effect of extreme drouth and a poor stand. The conditions in 1914, 1915, and 1916, however, were excellent for seed production, though in 1914 two cuttings of seed were obtained while in 1915 and 1916 only one seed crop reached maturity, which accounts for the difference in these two seasons. From these data and from observations made under field conditions in several sections of the state it is indicated that when but one seed crop is obtained, 1000 pounds or over may be considered an excellent yield, while the average production will probably range from 600 to 800 pounds per acre.

ENEMIES

Diseases.—As yet but few diseases have occurred on Sudan grass with sufficient severity to greatly injure the growth of the plants. Probably the worst and most prevalent disease is the sorghum blight or red spot, mentioned by Vinall in Farmers' Bulletin no. 605, and described as follows: "This disease is characterized by the appearance of distinct reddish spots or blotches on the leaves, these spots gradually spreading until the leaves turn brown and die. Its effect on

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the plant is much the same as rust and like rust, is most destructive in warm humid regions—but it seems possible to overcome this weakness by the production of disease-resistant strains.'' This disease has been observed upon nearly all Sudan grass plantings in this state, but in no case has it appeared to injure the growth severely.

Another disease to which Sudan grass is subject is sorghum smut. As yet, however, no reports of infection of this character have been received, nor is it apt to become prevalent or cause much damage since the grass will be used primarily as a hay crop.

Insects.—Probably the worst insect enemy of Sudan grass in California is the grasshopper. While no severe infestations have as yet been reported, it is known that grasshoppers feed abundantly on the green plants and may cause considerable damage during periodic outbreaks. Probably the best means of controlling this pest is by the distribution of poisoned baits around the edges of the field or between the rows. While the grass is small, the hopper dozer may also be employed with success.

Weeds.—Since Sudan grass is an annual and must be seeded every year and because of the rapidity and vigor with which it grows, weeds are not likely to be a serious menace to the crop. Such perennial weeds as Johnson grass and morning glory may, if present, reduce the stand and stunt the growth somewhat. The former plant is especially objectionable when a seed crop is to be grown since the plant itself and the seed can be distinguished from Sudan grass only with great difficulty. For this reason, a seed crop of Sudan grass should never be grown where Johnson grass is known to be present.

Source of Seed.—The original supply first distributed by the United States Department of Agriculture contained no Johnson grass seed. Seed growers and others who have produced their supply from this original source and have grown it on lands free from Johnson grass and on those not in close proximity to Johnson grass, should have pure seed. Our supply at the University Farm at Davis was secured and multiplied in this manner.

Sudan grass seed has now become a staple seed crop, and we find it quoted in the farm papers along with timothy and other well known seeds.

The seed has been grown to such an extent in states in which Johnson grass is known to flourish and produce seed that there is every possibility that some Johnson grass seed has crept in. It is very evident therefore that the above questions can not be satisfactorily answered. In regard to the probabilities of Sudan grass containing Johnson grass seed, however, we may be able to throw some light.

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Johnson grass is a perennial and produces strong pernicious underground stems or rootstocks, commonly called roots, each part of which when broken up in pieces, is capable of producing a new plant. These may descend to a depth of four or five feet in the soil. Under ordinary conditions of exposure, these roots are killed by freezing so that in those states where the soil freezes to a depth of several feet, Johnson grass is not likely to survive. This would include, in a general way, all the states north of Kansas and a large area in an irregular line where low winter temperatures prevail. Even in the states of Iowa and Michigan, the rootstocks have been known to survive the winters occasionally, but only under favorable conditions for protection from cold. According to Vinall, Sudan grass seed has been produced in Ohio, Minnesota and eastern South Dakota. Growers of Sudan grass for hay in states with cold winters, need not have the same fear of introducing Johnson grass, since if any seed should be present the plants from these would most likely be killed during the first winter.

It has been stated that Sudan grass can be readily distinguished from Johnson grass by its larger size and different color. Looking at either of them in bulk Sudan grass is generally plump and Johnson grass seed slender, but this can not be relied upon as individuals from a single plant of Sudan grass will vary greatly in this respect, due to the different stages of maturity of the seed and the cultural treatment of the plant. Again, Sudan grass is supposed to have light-colored seed, while Johnson grass is dark-colored. But there are good strains of Sudan grass that are quite dark in color, as well as light-colored Johnson grass seeds, so that color can not be relied upon in determining the purity of Sudan grass.

DISTINCTION BETWEEN SUDAN GRASS AND JOHNSON GRASS SEED

F. H. Hillman of the Seed Laboratory, United States Department of Agriculture, has recently discovered a method by which the dreaded Johnson grass can be distinguished from Sudan grass. We quote the following from the Weekly News Letter, U. S. D. A., vol. III, no. 36, April 12, 1916:

> Careful study of the seeds of these crops, which, though closely related and quite similar in appearance, differ greatly in their agricultural value, has resulted in the development of a method by which they can be distinguished through a careful and thorough examination with the aid of an ordinary magnifying glass which enlarges objects to the extent of six or eight diameters. A detailed technical description of the method has been prepared and will be published in the near future by the department, but in view of the widespread interest in the

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subject at this season of the year, when plantings of Sudan grass will soon be made, the following nontechnical description is published.

Seeds of Johnson grass are noticeably smaller than those of Sudan grass. When the two are mixed, seeds evidently smaller than others may be suspected to be Johnson grass.

In nearly all samples part of the seed is unhulled and part hulled. This is true of seed of both Johnson grass and Sudan grass. The smaller size of the Johnson grass seed is evident in both the unhulled and hulled seeds.

On closer examination under the magnifier, most of the unhulled seeds of Sudan grass are seen to have a short stem. Besides this, the two slender appendages lying on one face of the seeds are broken at the end. Most of the unhulled seeds of Johnson grass have no stem, but a smooth scar instead. The two appendages are mostly expanded and cup-shaped at the end. The stem and the broken appendages in Sudan grass seed and the smooth scar and entire expanded appendages in Johnson grass seed result from the fact that nature has made no special provision for the fall of the seed in Sudan grass, while in Johnson grass provision is made for the seed to separate from the plant at the junction of the seed with its stems cleaving a clean-cut scar. At this point a distinct line across the stem marks the point of separation. Exceptions to the general rule stated occur in both kinds of seeds. Some of the Sudan grass seeds have no stem, but the appendages are rarely entire and expanded at the end. Some Johnson grass seeds have a stem because of the weaker stem having broken more readily below its junction with the seed than at this junction. The appendages are rarely broken, and narrow at the end. Johnson grass seeds bearing a stem usually can be recognized by the distinct division line across the stem at its junction with the seed.

Some of the seeds of both Sudan and Johnson grass have a longer stem which is a part of the branch bearing the seed cluster.

Lastly, the free grains or hulled seeds of Johnson grass are smaller and darker colored than those of Sudan grass, and are usually oval in form, while those of Sudan grass are elliptical.

The Branch Seed Laboratory of the United States Department of Agriculture, at the College of Agriculture, Berkeley, is now prepared to report on the presence of impurities in Sudan grass seed, including Johnson grass.

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GRAIN SORGHUMS

BY

B. A. MADSON

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GRAIN SORGHUMS

By B. A. MADSON

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INTRODUCTION

The transition from extensive to more intensive methods of farming, together with the rapid development of the livestock industry which has taken place in California during the past few years, has created a demand for crops which would produce a dependable quan-

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tity of grain and forage on the vast areas of unirrigated land during the dry, hot, summer months. The crops which have thus far shown the greatest promise in filling this demand are the grain sorghums. While they are by no means new crops in this state, they have been of relatively little importance agriculturally since their production has been confined largely to a few rather circumscribed localities. For this reason general information regarding their production is lacking, as is evidenced by the large number of inquiries received by this department during the past three or four years. It is, therefore, the purpose of this publication to set forth briefly the information which has been gathered through experimentation and observations, with the hope that it may be of service to the farmer who is contemplating the production of these crops.

HISTORY IN CALIFORNIA

The history of the grain sorghums in this state, as well as in the United States, dates back to 1874, when a small consignment of White and Brown Durra was brought to California from Egypt. They were taken to the interior valleys, where they at once demonstrated their ability to withstand the hot, dry California summer, and very soon became established as a permanent crop. The Kafirs were introduced from the great plains a few years later and were followed in 1886 by Milo, which was brought from Texas. The latter crop soon demonstrated its superiority over the earlier introductions, and quickly attained a prominent place among the grain sorghums, a position which it has held to the present day,

While the grain sorghums have not risen into prominence as have some other crops, there, nevertheless, has been a normal and continual increase in their production. In 1899 the total acreage of grain sorghums in California was 20,218 acres, yielding 420,452 bushels of grain. In 1909 the acreage had increased to 44,308 acres, and the production to 938,049 bushels. Thus in ten years the acreage had increased 119.2 per cent, while the yield had increased 123.1 per cent. Unfortunately no statistics are available on the production since that date, but there is every reason to believe that the increase in production has been even greater than for the ten years given. Especially worthy of mention is the development of the grain sorghum industry in the Imperial Valley, in which section sorghum is at the present time one of the leading crops. The counties leading in the production of grain sorghums in 1909 were Tulare, Stanislaus, Kings, San Joaquin and Kern, in the order mentioned; the first three contained over one-half the total acreage of the state.

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ADAPTATION

Climatic Requirements.—The grain sorghums are of tropical origin, attaining their maximum development in regions having high temperatures and relatively low humidity during the growing season. Most of the varieties seem to be very susceptible to low temperatures, a fact which might militate against their use in sections where the average daily temperature during the growing season is low, or in sections having wide daily temperature ranges. Experiments and observations in this state, however, would seem to indicate that they can be grown successfully in all the interior valleys, and under these conditions constitute a very commendable substitute for corn. They have not, however, given as good results along the coast in regions subjected to the cool ocean breezes or at elevations above 5000 feet, though it is quite possible that varieties may yet be obtained which will give fair results even under these conditions.

Drouth Resistance.—All varieties of sorghums are drouth-resistant, and are considered among the surest of dry-land crops, though this quality is possessed to a greater degree by the grain sorghums than by any of the other types. Their ability to withstand drouth, however, is apparently due to their ability to make economical use of the water available rather than to their low water requirements.

While the grain sorghums as a class are comparatively shallow rooted, the roots are very much branched, completely filling the upper three feet of soil with a network of fine roots. This extensive root development, together with other physiological characteristics, enables them to utilize a larger proportion of the soil moisture than that used by most other plants. Furthermore most of the varieties are able to withstand a prolonged period of drouth without apparent injury.

Other things being equal, however, the yields obtained will usually be in direct proportion to the supply of moisture available. In many instances, with proper attention to details, good results have been obtained with a precipitation of eight to ten inches. When the precipitation is less than eight to ten inches, however, it is doubtful if paying returns can be obtained unless considerable moisture is carried over in the soil from previous seasons. With the annual precipitation greater than twelve inches good results can nearly always be obtained if proper precaution is taken to conserve the moisture.

Soil Requirements.—Grain sorghums may be grown on almost any soil that admits of ready cultivation. Like corn, they prefer a sweet soil, loamy in character and high in fertility. Very sandy soils or very heavy soils are not desirable. In the former type difficulty is often experienced in storing sufficient moisture for the use of the crop.

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Heavy soils, on the other hand, are difficult to handle, and are apt to be cold and in poor physical condition at the time for planting, which may result in a poor stand.

Soils containing alkali are also objectionable but the sorghums are more resistant to alkali than most field crops. Nevertheless, large amounts of soluble salts in the soil will exert an injurious effect upon the growth of the plants, thus decreasing the yield.

TYPES AND VARIETIES

The sorghums (*Andropogon sorghum*) include grain sorghums, sweet sorghums, broom corn, and probably also Sudan grass and Tunis grass, at least the relationship between the former and the latter two is very close. The division into agricultural groups or sub-species is based largely upon physical characteristics of the plants, and the purpose for which they are grown. Also rather closely related to the sorghums is Johnson grass (*Andropogon halipensis*), a well known weed pest in some portions of the state.

While the sorghums are self-fertile, a great deal of natural hybridization takes place under normal conditions, not only between varieties of the same type but between the various types. When different varieties of the sorghums or any of the sorghums and Sudan or Tunis grass are grown in adjacent fields, a large number of natural hybrids usually appear. This fact is significant as it shows the necessity of keeping the seed plats isolated in order to maintain a pure strain. Hybrids with Johnson grass, on the other hand, are apparently rare.

The grain sorghums are divided into groups as follows: Durras, Kafirs, Kaoliangs, and Shallu, this division being based largely on head and plant characteristics. The Durra group includes White and Brown Durra, Feterita and the Milos. As a whole they are early maturing, with rather short, dry, leafless stalks. The heads are thick, compact, ovate or egg shaped and may be either erect or pendent, depending upon the variety and cultural conditions. The White and Brown Durras, more commonly known as Jerusalem corn and Egyptian corn, have very dry, leafless stalks, with large, chaffy pendent heads and decidedly flattened seeds. The white-seeded variety shatters readily and is also often attacked by the birds. It is, however, the earliest maturing of the Durras.

Feterita, a rather recent introduction which has created considerable interest during the past few years, is rather tall, moderately leafy, with erect heads and plump bluish-white seed. It is early

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maturing and apparently equally as drouth-resistant as the other forms, but its seed is rather soft and of low vitality so that difficulty is often experienced in securing a good stand.

The Milos have somewhat finer, juicier stems, are more leafy, and stool or sucker more profusely than the other Durras. The heads of the Milo may be either erect or pendent, with large, protruding seeds. The Standard Milo and the Dwarf Milo are both yellow-seed forms, the latter being a selection of the former, having been developed for its shorter stems, earlier maturity and greater drouth-resistance. The White Milo resembles the Standard Milo except that it has white seed instead of yellow.

Fig. 1.—With a good stand and on strong land dwarf Milo will produce abundant yields of both grain and forage. Note the taller hybrids in the background.

The Kafir group includes all the various varieties of Kafirs, most of which produce rather large, leafy, slightly juicy stalks and are rather late maturing. The Kafirs are further characterized by having erect, slender, cylindrical heads with somewhat smaller seeds than the Durras. Of this group the principal variety grown is the Black Hull White Kafir, though within recent years an Early Black Hull and a Dwarf Black Hull Kafir, have been developed by selection from the former type. The latter varieties resemble the former except that they are both shorter in stature and earlier maturing. The other varieties of Kafir, including the White, Pink and Red, both because of the poor yield and late maturing, have ceased to be important.

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The Kaoliangs or Chinese sorghums have not been grown commercially in California as yet. As a class they are early maturing and possess small, dry, leafless stalks and erect, open heads. It is believed that they require less heat than either the Kafirs or the Durras and if this be true they might be of value at higher elevations or in sections where the growing season is too cool or too short for the latter types. As but little is known regarding their agricultural value, limited trials under the conditions mentioned are recommended before their production on a large scale is attempted.

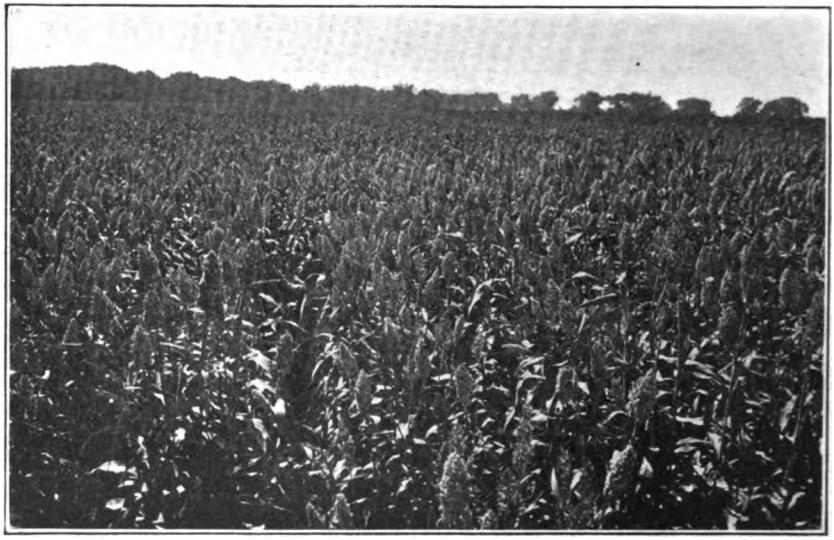

Fig. 2.—Feterita is not so resistant to adverse moisture and temperature conditions at the time of germination as other grain sorghums, but when a good stand is secured the yields are high.

Shallu, more commonly known as Egyptian wheat, differs from the former types in that it has rather large, dry stalks, very loose open heads and small, hard seeds, which, however, possess a high degree of vitality. Because of the latter character it is usually easier to secure a good stand with Shallu on soils that are cold and wet or of poor physical condition than with any of the other varieties.

In order to secure some information as to the relative value of the different varieties as grain crops, a variety test was begun at the University Farm at Davis in 1913. This test included not only

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the more common varieties but some of the more recent introductions as well. The yields obtained during the years 1913 to 1916 are given in Table I.

TABLE I

VARIETY TRIALS WITH GRAIN SORGHUMS
DAVIS

C. I. No.	Variety	Yield per acre, pounds 1913	1914	1915	1916	Ave.
	Durras					
332	Dwarf Milo	2605	4450	5031	2214	3575
234	Standard Milo	1492	3480	4830	2362	3041
.....	White Milo	.....	2860	4693	1974	3176
.....	White Durra	223	940	2520	378	1015
.....	Brown Durra	2813	3200	5071	1521	3151
182	Feterita	3164	2380	3139	1953	2909
	Kafirs					
340	Dwarf Black-Hull	959	2220	3209	1460	1962
472	Early Black-Hull	618	2450	2520	483	1518
185	Black-Hull White	64	2600	1968	463	1274
342	White Kafir	.....	1400	1533	1092	1342
34	Red Kafir	128	1250	1434	315	782
.....	Pink Kafir	.....	2475	2667	504	1883
	Kaoliangs					
310	Brachets Black-Hull	.....	.....	4662	777	2520
272	White Kaoliang	.....	.....	1071	325	698
170	Manchu Brown	.....	2000	4436	777	2404
171	Brown	.....	3700	4284	903	2962
.....	Shallu	.....	4200	4609	1816	3542

In studying the data given in the table it will be noted that there is considerable difference between the yields of any single variety for the different seasons. The relatively low yield of all varieties in 1913 was due to drouth, the total precipitation being less than nine inches. In 1916 the yields were also rather low. This, however, was due primarily to the poor stand obtained in most cases. In the absence of spring rains the soil became very dry before planting time, rendering the preparation of a good seed bed almost impossible. The conditions during the two seasons 1914 and 1915, on the other hand, were good and the results obtained were excellent.

Considering the average yield of the varieties by groups, it will be noted that of the Durras the highest yield was produced by Dwarf Milo, with 3575 pounds per acre, followed by White Milo, Brown Durra and Standard Milo, respectively. Attention is called to the fact, however, that the White Milo was not grown during the dry

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season of 1913, but was grown only during the three most favorable seasons, and that the yield during these three seasons was lower than the yield of either Brown Durra or Standard Milo.

The lower yield of Feterita as compared with the former varieties is unquestionably due, in nearly all cases, to a poor stand. Nevertheless this factor is an important one when considering the relative merits of the different varieties. The low yield of the White Durra may be accounted for by losses through shattering and by attacks of

Fig. 3.—A plot of Dwarf Milo from selected heads. Note the large well-developed heads.

birds, 60 to 80 per cent of the grain usually being destroyed before it is mature.

Of the Kafirs the Dwarf Black-Hull Kafir gave the largest average yield, followed by Pink Kafir, Early Black-Hull, and Black-Hull White, respectively. The Dwarf and the Early Black-Hull are both more dwarfed in stature and earlier maturing than the Black-Hull White, and as grain crops are apparently better adapted to the conditions at Davis than the last named variety. The yield of the Pink Kafir has been fair, but it is very late in maturing and its seeds are rather dark and astringent, making it an undesirable variety to grow. The same in general may be said of the Red Kafir. The White Kafir, on the other hand, is a small, early maturing variety, but has little in its favor as a grain crop.

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Of the Kaoliang group the best results have been obtained from Brown Kaoliang, though it must be stated that in manner and habit of growth, this variety and the Manchu Brown appear to be identical. Brachets Black-Hull Kaoliang, a rather dwarf, leafy variety, has given fair yields of grain during the two years it has been in the experiments. White Kaoliang, a very tall, though early maturing variety, is always attacked by birds, which accounts for its low yield.

The yield obtained from Shallu, it will be noted, is exceeded only by Dwarf Milo. This variety, however, was grown only during the last three years, giving it the advantage of the more favorable seasons.

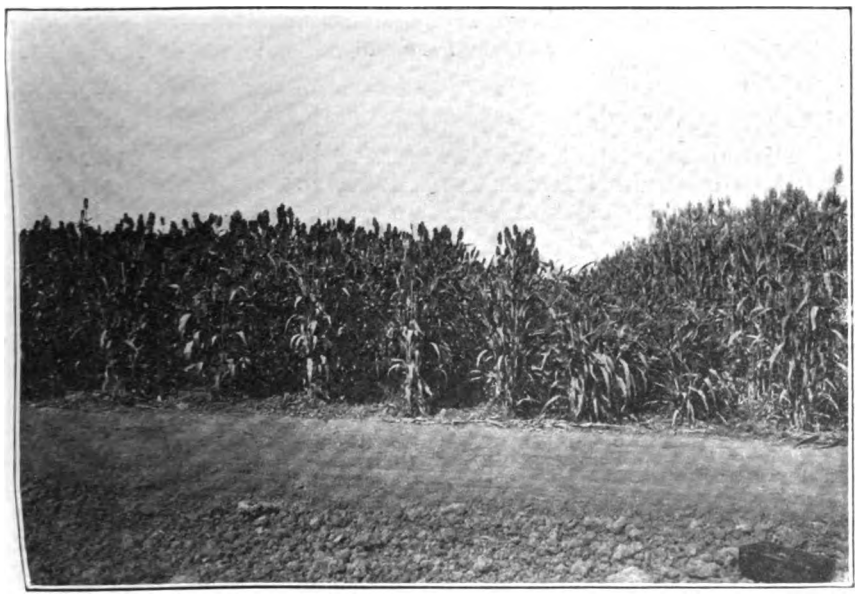

Fig. 4.—Brown Kaoliang on the left, Dwarf Milo in the center, and White Kaoliang on the right.

It may be said, however, that the yield from Shallu is nearly always good and especially so when the supply of moisture is abundant. It is, however, later maturing and its seeds are small and hard, making them less desirable for feed than most of the other sorghums.

Considering the results as a whole the Durras have given higher yields than the varieties of any of the other groups, while the Dwarf Milo has been the most promising variety of the lot, and is without question the best variety for most conditions when a maximum yield of grain is desired. Regarding the other Durras, their relative worth will be determined by specific conditions and by the purpose for which they are to be grown. The yields of the Kafirs, on the whole

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have been low, and it is questionable if they can be recommended for general use in this state except where grain and forage both are desired, and where the growing season is long.

A test including a few of the Durras and Kafirs was also conducted at the Kearney Park Station in 1913. In this test all the varieties were so badly injured by birds that the results were materially affected. An attempt was made to estimate the approximate percentage of injury in each case, which, together with the yields obtained, is given in Table II.

TABLE II

VARIETY TRIALS WITH GRAIN SORGHUMS
KEARNEY PARK, 1913

Variety	Per cent destroyed by birds	Yield per acre, pounds
Dwarf Milo	50	1739*
Standard Milo	60	1731*
White Durra	75	177†
Brown Durra	55	1817†
Feterita	40	1833
Dwarf Black-Hull Kafir	60	924
Early Black-Hull Kafir	60	770
Black-Hull White Kafir	50	429†

* Average of three plots.
† Average of two plots.

The results here obtained were practically the same as the averages of the four years at Davis. While Feterita gave a slightly higher yield than the Milos and Brown Durra, only one plot of the variety was grown, and it may be stated that the Dwarf Milo plot adjacent to the Feterita plot yielded 2285 pounds per acre or 450 pounds more than the Feterita. Furthermore the Feterita was not so much damaged by the birds as were the other varieties.

All the Kafirs gave low yields but the order of their importance as indicated by yield was the same at Kearney Park as at Davis.

CULTURE

Inasmuch as the grain sorghums are summer-grown crops, making their growth during the dry season of the year, too much emphasis cannot be placed upon the preparation of the seed bed and the care of the crop during the growing season. Especially is this important since the grain sorghums will, in most cases, be grown as a dry-land crop. We should not lose sight of the fact that although they are as a class drouth resistant, the yields which will be obtained will usually

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be in direct proportion to the condition of the soil and the amount of moisture available. It is therefore desirable to handle the soil so that a good seed bed can be prepared and as much of the precipitation conserved as possible.

Preparation of the Seed Bed.—When possible the land should be plowed in the fall or early winter to a depth of eight or ten inches and allowed to lie in the rough until spring. In this condition the soil will absorb a large proportion of the winter rainfall and will also be materially benefited by weathering action. Unless the field is very weedy no further treatment will be necessary until it is to be prepared for seeding, at which time the seed bed can usually be prepared with a disc and harrow. If for any reason spring plowing becomes necessary it should always be more shallow than fall plowing, otherwise too much moisture will be lost by evaporation and difficulty will be experienced in working the land down properly for seeding. In fact, except on the most favorable soil more work is always required to prepare a good seed bed on spring-plowed than on fall-plowed land.

The seed bed should be smooth and even, with a mulch of two to three inches on the surface, while the soil below the mulch should be firm and moist. This condition is imperative as the seed of most of the grain sorghums is rather soft and rots easily if the soil is too cold or porous or the moisture supply insufficient for prompt germination. As has formerly been stated, such a seed bed can in most cases be prepared on fall-plowed land without difficulty with the ordinary implements found on the farm. Spring-plowed land, however, may require more work in order to pack the subsoil sufficiently and to pulverize the surface properly.

Time of Seeding.—The time to plant the grain sorghums will vary to some extent with the location and with the character of the soil. Planting should not be done until the soil and atmosphere are quite warm. In the valleys in the southern portion of the state where the warm weather begins earlier in the spring the crop may be planted earlier than in the north. Again, light, sandy soil warms up more quickly than heavy soil and can usually be planted a week to ten days earlier than the latter type. Results obtained at Davis indicate that in that section at least, the best time to plant is from the 10th to the 20th of April. If planted earlier the atmosphere and soil are too cold for the best growth. On the other hand, if planting is delayed until after the first of May the soil is apt to become too dry for prompt germination unless irrigation can be provided. On irrigated land seeding may be delayed until the middle or latter part of June, though the total yield will seldom be as great as when planting

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is done earlier. In some places, however, this fact is made use of by employing the grain sorghums as a second crop to follow grain, grain-hay, or other similar spring crops.

Method and Rate of Seeding.—The most common method of planting the grain sorghums is to use a corn planter fitted with sorghum seed plates. With this implement the seed is drilled in rows three to three and one-half feet apart, spacing the seed from four to six inches apart in the row. In some cases the grain drill has been used for planting the crop by stopping up enough of the holes to give the proper spacing between rows. This implement, however, is not to be recommended as it seeds too shallow and too heavily for any but the most favorable conditions.

The distance commonly allowed between the rows is three and one-half feet, since this distance provides ample room for the development of the plants and for cultivation.

The distance between the plants in the rows will be governed by the character of the soil and the supply of moisture, and also by the variety employed. On fertile loam soils abundantly supplied with moisture, the heavier rates of seeding may be employed, while on sandy soils with a limited supply of moisture it is often advisable to allow a distance of even ten to twelve inches between the plants in the rows. Again such short varieties as Dwarf Milo and others of the Durras can ordinarily be seeded heavier than such large leafy types as the Kafirs, since the individual plants do not require as much moisture or as much space for development as do the plants of the latter type. In the case of the Milos especially, it is usually advisable to seed as heavily as conditions will permit, otherwise the plants stool profusely, causing uneven development of the heads as well as uneven ripening. All of the Durras and some of the Kafirs, if provided with ample room, will stool to some extent, but none of them stool as prolifically as the Milo.

The amount of seed ordinarily required per acre will be from two to six pounds. When planting the sorghum crop care should be exercised to see that the seed is placed below the surface mulch in contact with moist soil where it may quickly absorb the water needed for germination. This will usually be at a depth of from two to three inches. If the seed bed is rough and open, however, as is often the case on spring-plowed land, deeper planting may be advisable, though the maximum depth on ordinary soil is probably about four inches. If planted too shallow, the seed will be placed in the dry mulch, where germination will be delayed, which will often result in a poor, uneven stand.

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When the surface of the soil is rough and open or the layer of dry soil so deep that it is difficult to get the seed down to moisture, good results have often been obtained by attaching shovel furrow openers on the shoes of the planter. These shovels provide small furrows by pushing the clods and dry soil aside, thus making it much easier to get the seed down to the moist soil below. This provides a condition much the same as that obtained by listing, except that the furrows are smaller and much shallower, being no deeper than necessary to get the seed below the mulch.

Listing sorghums has not been practiced to any great extent in this state, though it probably could be employed to advantage especially on light soil or for late planting. When planted with a lister the seed is planted in the bottom of a furrow several inches below the normal level of the ground. This furrow is allowed to remain open until the plants attain some size, when it is gradually filled in by the successive cultivations. When planted by this method the main roots of the plants are forced to develop several inches below the surface of the soil, making it possible to maintain a deeper mulch without injuring the roots.

On soils that are heavy or wet, however, listing may be a disadvantage since the soil in which the seed is planted may be too cold for rapid germination, or the bottom of the furrow may bake so hard that the young plants will be unable to force their way through.

Care of the Crop.—The attention necessary after the crop has been planted will depend wholly upon the condition of the field and the season. The sorghums grow rather slowly at first, and it often happens that the field becomes foul with weeds before the plants are large enough to permit regular cultivation. When this occurs the weed growth may be destroyed by the use of a harrow without severe injury to the crop, provided the teeth are set at an angle of forty-five degrees. Again, if the soil becomes crusted due to rains, as frequently occurs on heavy soils, the crust must be broken as the young seedlings are often too weak to push their way through. If the crust is not too thick it may be broken with a harrow, though it is usually better to use a corrugated or dunham roller, as this implement breaks the crust without injury to the plants. In general it may be said, however, that either the harrow or the roller can be employed with safety until the plants attain a height of four or five inches.

As soon as the plants are large enough so that the rows can be plainly seen the field should be cultivated, using an ordinary two-horse corn cultivator. This cultivation should be at least four inches in depth as the main object beside the destruction of weeds is the

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establishing of a deep mulch. For this purpose an implement with rather small shovels is to be preferred since it pulverizes the soil more thoroughly and leaves the surface relatively smooth and even. Two or three similar cultivations should be given at intervals of from two to three weeks or until the plants attain a height of about three feet, after which no further cultivation will be necessary. Normally the crop will continue growth and mature without further attention.

Irrigation.—While the larger proportion of the grain sorghum crop will probably be grown without irrigation, occasions may arise under which irrigation may be advisable. Especially is this true when the sorghum is to be grown as a second crop following grain-hay or some similar spring crop. In such cases it will nearly always be necessary to irrigate the land before seeding.

The time of irrigating and the number of irrigations after the crop has been planted will depend wholly upon local conditions. Water should be applied when the plants appear to be affected by drouth. Except when the natural precipitation is very low one irrigation will usually be sufficient, this being applied when the plants start to head.

For irrigating the sorghums the furrow method may be employed, but if the land has previously been leveled and checked flooding is usually preferred because of the smaller amount of labor involved. After irrigation the field should be cultivated as soon as the soil is dry enough to work properly.

HARVESTING THE GRAIN CROP

The time of ripening will depend not only upon the time of planting, but also upon the location, and the season, as well as the variety. Where the average daily temperature is high the crop will mature much more quickly than where it is low or in sections having cool nights. For example, in the Imperial Valley or in the southern part of the San Joaquin Valley, Dwarf Milo will often mature in 100 to 115 days after the plants are up, whereas at Davis, where the nights are relatively cool, 125 to 140 days are normally required. A similar variation in the time of maturity has been noted with the varieties requiring a longer season.

The grain crop should not be harvested until the majority of the heads are fully mature, since immature seed is apt to heat in storage, causing a considerable loss. The common means of harvesting this crop is to cut the heads by hand, throwing them into a wagon and hauling to the curing beds. By this method one man with a team can harvest from three-fourths of an acre to one acre per day, de-

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pending upon the character of the field. Dwarf varieties with rather erect heads are sometimes harvested with a grain header. It is necessary, however, to modify the implement somewhat by raising the cutting device in order not to cut too much of the stalk. At best, some heads will be left in the field which must either be gathered by hand or pastured off by livestock. The corn binder is also employed to a slight extent, the stalks being cured in the field and later hauled to the barnyard and either headed or fed directly to livestock. Heading from the stack or shock, however, is much slower than heading from the standing crop. If the stalks are bound in bundles, however, they may be headed rather rapidly by laying the bundle on a block and cutting off the heads with a broadaxe or corn knife.

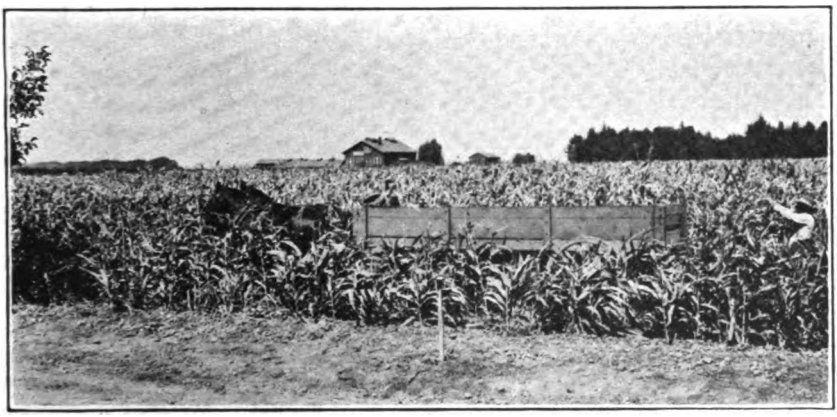

Fig. 5.—Harvesting Dwarf Milo at the University Farm.

After the heads are harvested they must be thoroughly cured. In sections where the conditions for drying are good the heads are usually placed in piles or ricks five to six feet in height, where they are allowed to remain for ten days, two weeks, or longer if necessary, until they are thoroughly dry. In sections where the conditions for drying are less favorable smaller piles must be used, otherwise the grains may spoil on the head. A method employed at the University Farm with good success is to spread straw on the ground to a depth of six to eight inches and then to spread the heads on the straw to a depth of a foot or eighteen inches, in which condition curing will take place rather quickly. When taken from the curing bed the straw is run through the thresher with the grains, thus preventing the usual loss due to shattering.

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For threshing the grain sorghums, the ordinary grain thresher may be used if modified slightly. Most manufacturers of threshing machines supply special riddles to be used, which greatly facilitate the cleaning of the grains. The same riddles and sieves as are used for barley may be employed, though their use usually makes it necessary to reclean the seed after threshing. Another modification necessary is a removal of some of the concaves and a reduction in the

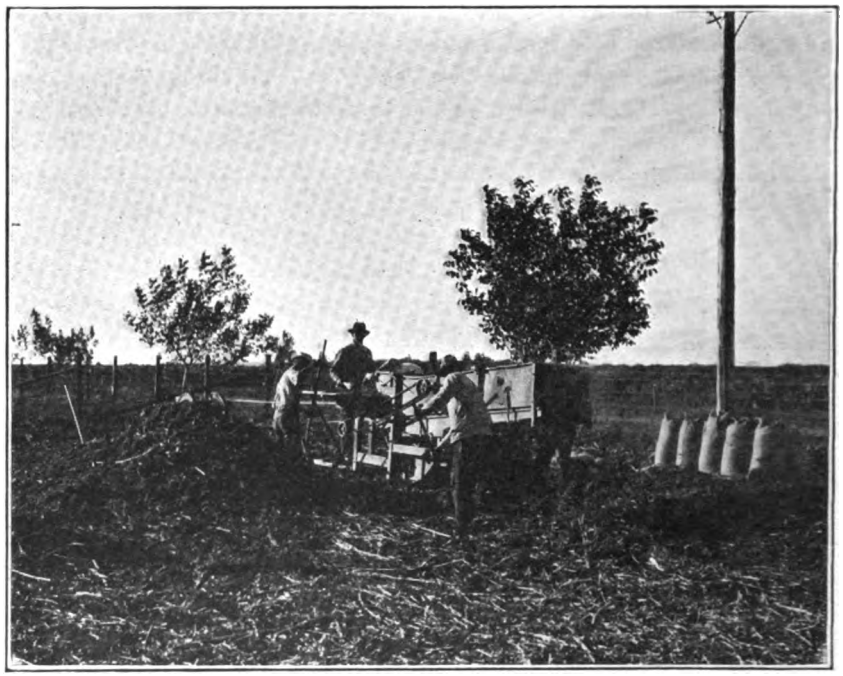

Fig. 6.—Threshing Milo at the University Farm.

speed of the cylinder, in order to prevent the cracking of a large percentage of the grains.

The grain is usually stored in bags rather than in bulk, since by this method it is easier to keep it from heating. Storing in bulk, however, may be practiced if it is kept perfectly dry and very large quantities are not placed in one bin. Because of the rather soft character of the seed, however, it absorbs moisture easily and will quickly spoil if not properly cared for. Even when placed in bags, the bags should be stored in as dry a place as possible, with ample circulation of air provided to keep it dry.

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GRAIN SORGHUMS AS FORAGE CROPS

The grain sorghums have not as yet been used extensively for forage, though it has been shown that when employed as stover, fodder or silage they compare favorably with corn. The choice of varieties for this purpose will naturally differ somewhat from the selection for grain alone. In general, the varieties which produce the largest vegetative growth and are the most palatable should be employed. In many respects the Kafirs are to be preferred since they not only produce a high tonnage but their stalks are leafy, somewhat juicy and quite palatable. The Milos are also excellent for this purpose, being apparently equally palatable to the Kafirs, though the tonnage which they will produce will ordinarily be less. Such varieties as White and Brown Durras or Shallu, because of their dry, pithy stalks, and lack of leaves, yield a low tonnage of forage of very poor quality.

Unfortunately no extensive tests have been conducted to determine the relative forage yields of the different varieties. During the seasons 1914 and 1915, however, the total green weight produced in the different cases on the Agronomy plots was determined by harvesting the whole plot as soon as the grain was mature and before the leaves had withered. The average yields of both grain and stalk, in tons per acre for the two years, of the varieties most suitable for forage purposes, were as follows:

	Tons per acre
Dwarf Milo	9.80
Standard Milo	9.93
White Milo	10.58
Feterita	7.01
Dwarf Black-Hull Kafir	12.35
Early Black-Hull Kafir	14.67
Black-Hull White Kafir	16.06

The cultural methods to employ when the crop is grown for forage are in most cases the same as those used for grain production. When the moisture supply is abundant it may be permissible, in most cases, to seed a little more heavily as by so doing the yield, as well as the quality of the forage, will be improved.

The proper time for harvesting will vary a little, depending upon the manner in which the forage is to be used; but since the stems and leaves of most of the grain sorghums remain green until after the seed is ripe, it is usually better to allow the seed to become mature before harvesting. If sorghums are to be used for silage this is

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absolutely necessary in order to make the best quality of silage. If the product is to be fed as fodder the crop can be harvested when the seed is in the hard dough stage.

The sorghum forage crop may be harvested in exactly the same manner as corn. When the acreage is small, harvesting by hand or with a sled cutter will probably be most economical, but where large areas are to be handled it will usually pay to secure a corn binder which ties the plants into bundles, making them much easier to handle.

If the crop is to be used for silage it should be put into the silo as soon after cutting as possible, but if it is to be used as fodder the stalks or bundles should be put into shocks in the field and allowed to cure thoroughly, after which they may either be stacked or hauled directly to the feed rack.

GRAIN SORGHUMS IN THE ROTATION

The use of the grain sorghums in the rotation has been a rather perplexing problem since they have the unsavory reputation of being "hard on the land." Just why this crop is hard on the land is not definitely known, but it is true that if such a rapid growing crop as barley is seeded on the land immediately following grain sorghums the yield will not be as good as if preceded by some other crop. It is probable that the sorghum, the root system of which is bunched near the surface, draws heavily on the available plant food and moisture, thus lessening the supply for the crop immediately following, especially if that crop is one which demands these constituents in relatively large quantities. It is evident that as compared with corn the grain sorghum leaves the soil in poor physical condition. Tests at the University Farm have shown, however, that if a couple of months elapse between the time the sorghum crop is removed and the seeding of the barley, the detrimental effect will be greatly lessened. When such a system is to be followed it is advisable to plow up the sorghum stubble as soon as the crop has been removed as areation will then be more thorough and the injurious effect more readily overcome. Wheat and oats are not affected as much as barley, while intertilled crops seem to be affected even less.

Another problem that will arise is the proper disposition of the stalks when they cannot be used for feed. While definite information is lacking as to the best means to dispose of them, it will probably be best to cut and remove them from the field, especially in sections where the moisture supply is low. While the writer is aware that this is contrary to the best agricultural teaching, yet it has been

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found that with a low rainfall the soil moisture will be insufficient to rot so large a quantity of material and trouble will follow. Even when the stalks are removed, difficulty will sometimes be experienced in disposing of the stubble and roots. By using a fourteen or sixteen-inch mouldboard plow, however, the stubble may be turned under with a fair degree of success, but the ten or twelve-inch plows commonly found on California farms are too small to perform the job in a satisfactory manner. If the plowing is done in the fall or early winter, the large crowns will ordinarily be sufficiently disintegrated by spring so that they will not cause trouble when preparing for most spring crops. Sorghum, however, is not a good crop to precede alfalfa as even under the most favorable conditions the roots and stubble are apt to prove troublesome in leveling and checking the land as well as in seeding the alfalfa.

The grain sorghums may apparently follow almost any other crop with fair success, though it is not advisable to grow this crop on the same land year after year without the use of some other crop in the rotation. A system which is finding some favor where irrigation is available is to utilize the grain sorghum as a second crop following grain hay. The hay crop is removed in May or early June and the land irrigated and plowed and planted to sorghum. For this purpose an early maturing variety such as Milo, White Durra, or Feterita should be employed to avoid the possible danger of the crop being injured by frost before maturity. Even these vareties can not be planted later than the 20th of June without incurring the possible danger of injury by frost before maturity takes place in most sections of the state.

SEED SELECTION AND IMPROVEMENT

As yet but little effort has been made to improve the grain sorghums, though from the small amount of work that has been done it is apparent that a great deal of progress can be made in this direction. By intelligent selection the yield of grain and forage may be greatly increased, as may also the earliness of maturity and drouth resistance. With such varieties as the Milos, which normally have rather pendent heads, it is possible, through careful selection, to develop in a very short time a strain with perfect heads. Many other similar lines of improvement will naturally suggest themselves, but the growers should bear in mind that it is much more difficult to fix several characters than one or two, for which reason only such characters should form the basis of selection as will be of value under his particular conditions.

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While the majority of growers may not care to attempt improvement of the crop as above suggested, all are strongly urged to maintain seed plots, especially if they desire to grow the crop year after year. This is especially desirable as the seed on the market is often badly mixed with other varieties as well as badly hybridized with these varieties.

Inasmuch as all varieties of sorghums cross rather readily the seed plot should be maintained in an isolated part of the field where it will not be crossed by other varieties. The seed for this plot should be from heads or plants of a uniform type, for by careful selection of the few heads necessary to plant the seed plot, the grower is able not only to purify his strain, but to increase the yield and quality of his product as well.

VALUE AS FEED

Relatively little information is available concerning the feeding value of the grain sorghums, especially as compared with the other cereals, but such tests as have been conducted indicate that when fed either as grain or in the form of fodder or silage they compare favorably with corn. It should be remembered, however, that the grain of the sorghums, like that of the other cereals, is not in itself a balanced ration, and will, therefore, give the best results only when fed in conjunction with some more concentrated feed.

In order to determine the relative composition of the different varieties analyses were made on the grain of the 1914 crop, the results of which, together with the analysis of corn and barley, are given in table III.

Comparing the average composition of all the grain sorghums with corn and barley it will be noted that they are but slightly lower in protein, fat, and crude fiber than corn, but higher in carbohydrates and ash. Barley is somewhat higher in protein, crude fiber and ash, but considerably lower in fat and carbohydrates.

A rather wide variation in the composition of the different varieties was obtained, but attention is called to the fact that the data given in the table represent but one analysis of each variety, and perhaps, therefore does not give an accurate comparison under all conditions.

As a grain feed, it is pretty well understood that there is some difference in value between the different types and varieties not shown in the composition. The Brown Durra and the Kafirs, for instance, are prone to have a constipating effect on the digestive system of animals unless fed with a laxative feed such as oilmeal or alfalfa.

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TABLE III

COMPOSITION OF GRAIN SORGHUMS[1]
1914 CROP

Variety	Per cent					
	Water	Protein	Fat	Crude fiber	Carbo-hydrates	Ash
Durras						
Dwarf Milo	10.05	8.99	3.35	1.91	74.25	1.45
White Milo	11.75	8.31	2.85	1.73	73.86	1.50
White Durra	11.00	10.58	3.62	1.30	71.36	2.14
Brown Durra	11.30	10.75	3.18	1.60	71.28	1.85
Feterita	11.35	9.49	2.12	1.33	74.21	1.50
Average all Durras	11.09	9.62	3.02	1.58	72.99	1.69
Kafirs						
Dwarf Black-Hull Kafir	11.82	9.66	3.90	2.13	70.69	1.80
Red Kafir	12.75	9.49	3.10	1.68	71.32	1.66
Pink Kaffir	12.74	9.32	3.28	2.37	70.35	1.49
Average all Kafirs	12.44	9.49	3.43	2.06	70.79	1.65
Kaoliangs						
White Kaoliang	10.82	11.68	3.90	2.45	68.59	2.56
Manchu Brown Kaoliang	9.78	9.32	3.71	1.33	74.48	1.38
Brown Kaoliang	10.19	10.25	3.36	1.75	72.27	2.18
Brachets Black-Hull Kaoliang	12.35	9.66	3.20	2.41	70.33	2.05
Average all Kaoliangs	10.78	10.23	3.54	1.98	71.42	2.04
Shallu	12.85	9.28	3.93	1.63	70.74	1.57
Average all sorghums	11.44	9.76	3.34	1.76	71.82	1.78
Corn[2]	10.60	10.30	5.00	2.20	70.40	1.50
Barley[3]	10.90	12.40	1.80	2.70	69.80	2.40

[1] Analyses of sorghums made by Professor M. E. Jaffa.
[2] and [3] Taken from Jordan's "Feeding of Farm Animals."

With the White Durra and the Milos, however, no effect of this character has been noted, a fact which renders them especially desirable as calf or poultry feeds. When the sorghums are used as grain feed much better results will usually be obtained if the seed is ground or crushed than if fed whole. When fed to livestock good results are also obtained by grinding or crushing the whole heads. The feed thus obtained compares favorably with corn and cob meal.

For fodder or silage purposes the value as a feed is governed to some extent by the variety and by the time of harvesting. However, where properly handled the fodder or silage from the Kafirs or Milos is but slightly inferior to corn. Much still remains to be learned, not only with regard to the value of the sorghums as feed, but also with regard to the most economical means of feeding them. When these problems have been more fully worked out and the value of the crops

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as feed better understood it will doubtless lend a strong impetus to the production of this crop.

Danger from Poisoning.—Considerable apprehension is felt regarding the danger to stock from poisoning where the sorghums are fed green. It is true that plants which have been stunted in their growth sometimes develop prussic (hydrocyanic) acid in their leaves, which is quickly fatal to the animals which eat it. Most of the loss from poisoning, however, has occurred by pasturing stock on second-growth sorghums after the first crop has been removed. This second growth is made at a season of the year when the soil is dry and the conditions for growth not wholly favorable. The first growth seldom, if ever, causes trouble and can be either pastured or fed green without danger. In curing, the prussic acid disappears, so there is absolutely no danger in feeding the stover or fodder.

ENEMIES OF THE GRAIN SORGHUMS

The grain sorghums grown in this state have been remarkably free from pests, either in the form of insects or diseases. The sorghum grain smut is sometimes met with, but seldom is the infection bad enough to occasion great loss. This disease resembles somewhat the stinking smut of wheat and can be controlled either by soaking the seed for fifteen minutes in hot water (132° to 134° F), or by dipping for ten minutes in a solution of formaldehyde (one pound of formaldehyde to forty gallons of water). After treatment the seed should be dried immediately and seeded as soon as possible. It is stated[4] on good authority that the Yellow Milo is immune to this disease.

Undoubtedly the most destructive pest of the grain sorghums in this state are blackbirds, and their control is not only difficult but probably impossible. Some of the varieties, such as White Durra and the White Kafir, are apparently preferred by the birds, but the other varieties are by no means immune to their attacks. This preference is sometimes made use of by planting a few rows of the varieties desired by the birds around the main field as a trap crop to attract the birds from the main portion of the field. It is necessary, however, to use a variety which matures as early as the main crop, the White Durra probably being the variety most commonly used.

[4] Farmers' Bulletin 288, p. 26.

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SUMMARY

1. The first introduction of grain sorghums into the United States occurred in 1874 when White and Brown Durra were brought to California from Egypt. Since that date their production in this state has increased gradually.

2. Sorghums prefer a warm, dry climate, relatively low in humidity. Localities with relatively cool conditions during the growing season or great daily temperature ranges are least suited to the growth of this crop.

3. The grain sorghums will withstand more drouth than most other field crops grown in California. However, since they are summer-grown crops, they must depend upon the water stored in the soil for their moisture supply. For this reason free-working loam soils with a large water-holding capacity are to be preferred.

4. Variety tests at the University Farm at Davis indicate that Dwarf Milo is the best variety for grain. All the Durras, however, are more prolific grain producers than the Kafirs.

5. In preparing the field for sorghums the land should be plowed in the fall or early winter to facilitate the absorption of moisture and the subsequent preparation of the seed bed. A well-prepared seed bed is necessary for sorghums in order to insure prompt germination of the seed.

6. The grain sorghums should not be planted until the soil and atmosphere are quite warm. At the University Farm the best results were obtained by planting between the dates of April 10 and 20. The corn planter fitted with sorghum seed plates is the implement commonly employed for planting the crop.

7. The amount of seed required per acre will vary from four to seven pounds, depending upon conditions. The distance between the rows and the rate of planting in the row must be governed by the variety and the amount of moisture available.

8. Listing sorghums has not been practiced to any great extent but may be advantageous on light dry soil or for late planting.

9. After the plants come up they should be cultivated often enough to keep the weeds in check and to maintain the mulch.

10. Grain sorghums are usually harvested by hand although the grain header or the corn binder may be employed. After harvesting it is necessary to cure the heads thoroughly before threshing, as the seed is otherwise apt to heat in storage.

11. For forage purposes the Kafirs and Milos, because of their juicy stems, are preferable to most of the other varieties. In using

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the grain sorghums for silage the seed should be allowed to mature before harvesting in order to secure the best quality of silage.

12. Grain sorghums are hard on the soil and are not a good crop to precede such a rapid-growing crop as barley. This effect, however, can be overcome by plowing the field and allowing it to lie idle for a couple of months before seeding to another crop. Early maturing varieties of grain sorghums may be used as a second crop to follow grain hay.

13. Grain sorghums when fed either as grain fodder or silage are but slightly inferior to corn in feed value. Second-growth sorghums may develop prussic acid, which is poisonous to stock; the first crop, however, seldom if ever develops poison, nor is this found in the dry forage.

14. The worst enemies of grain sorghums in California are blackbirds, against which no adequate means of control have been devised.

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IRRIGATION OF RICE IN CALIFORNIA

BY

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U. S. Department of Agriculture

(Based on work done at various periods during the years 1913–1916 in cooperation with the Office of Public Roads and Rural Engineering, U. S. Department of Agriculture, the California State Department of Engineering, the Office of Cereal Investigations of the Bureau of Plant Industry of the U. S. Department of Agriculture, and the California State Water Commission.)

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IRRIGATION INVESTIGATIONS

(In cooperation with Office of Public Roads and Rural Engineering, U. S. Department of Agriculture, and State Engineering Department of California)

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IRRIGATION OF RICE IN CALIFORNIA

By RALPH D. ROBERTSON

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INTRODUCTION

From two and one-half to three acre-feet of irrigation water per acre per year is sufficient for the growth of maximum economic yields of alfalfa on the medium loam soils of Sacramento Valley. This is the conclusion drawn from experiments covering a six-year period at the University Farm at Davis, and of observations during one to two years on fifty-four Sacramento Valley alfalfa farms.

In addition to the particular studies from which the above conclusion is drawn, these experiments and observations have been concerned with the duty of water for alfalfa on both the lighter and the heavier soils of the valley, the quantities of water it is desirable to apply to Sacramento Valley alfalfa fields at single irrigations, desirable irrigation "heads" for Sacramento Valley alfalfa fields, the percentage of moisture in the soil necessary to prevent wilting, and the amount of moisture above the wilting percentage that produces the most satisfactory growth.

EXPERIMENTS AT THE UNIVERSITY FARM AT DAVIS

The duty-of-water experiments conducted at Davis covered the period 1910 to 1915, inclusive. During 1910 and 1911, 8.19 acres in square and contour checks, each 0.20 to 1 acre and averaging 0.28 acre in area, were utilized. From 1912 to 1915 the work was confined to 3.48 acres divided into 15 square checks averaging 0.23 acre each. The soil of these plats is classed by the Bureau of Soils and the University of California Agricultural Experiment Station as Yolo loam.[2]

In addition to check plats which were not irrigated, the various annual depths of water applied were 12, 24, 36, and 48 inches, for the full six years of the experiment, with additional plats receiving annual

---

Frank Adams, Ralph D. Robertson, S. H. Beckett, Wells A. Hutchins, and O. W. Israelsen, printed in the fifth biennial report of the California State Department of Engineering, and reprinted as Bulletin No. 3 of that department. The investigations were made as a part of the co-operative irrigation investigations in California conducted under agreement between the Office of Public Roads and Rural Engineering (prior to July 1, 1915, the Office of Experiment Stations) of the United States Department of Agriculture, the State Department of Engineering of California, and the California Agricultural Experiment Station. The work at the University Farm at Davis has been under the local supervision of Professor S. H. Beckett, assisted by O. W. Israelsen and Roy Wray. The work on Sacramento Valley alfalfa farms and on the temporary experimental plat at Willows was done under the immediate supervision of Ralph D. Robertson, assisted chiefly by Wells A. Hutchins. Soil moisture studies were largely made by O. W. Israelsen.

[2] U. S. Dept. of Agr., Bureau of Soils, Reconnoissance Soil Survey of the Sacramento Valley, California.

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depths of 18 inches and 60 inches during the last four years of the experiment.

The total depths of 30, 36, 48, and 60 inches were given in individual applications of 7.5 inches, 9 inches, 12 inches, and 15 inches, respectively. In 1910, 1912, and 1913, following winters of low rainfall, the first irrigations were given immediately after the first cuttings, but in 1911, 1914, and 1915, following relatively wet winters, irrigation began after the second cutting.

All of the plats were large enough to represent normal field practice, so the work should be classed as field experiments rather than laboratory experiments. Irrigation water was supplied from a pumping plant on the tract delivering approximately 0.9 cubic foot per second.

Throughout the experiments the practice followed was to irrigate just as soon as possible after removing the crop from the field. Because of the small irrigating head available, slip-joint pipe was used on the larger checks to aid in even distribution.

In the time of cutting, raking, shocking, and hauling the hay standard field practices always were observed. That is to say, the alfalfa usually was cut when one-tenth to one-third in bloom and the hay generally was raked the same day, shocked the following day, and hauled as soon as it was dry enough to be stacked without heating, never being left until the leaves were dry enough to fall off when handled. The curing and removal of the hay from the field required from five to seven days.

The following table summarizes the results of these experiments at Davis over the full six-year period, including the average cost of production and the average profit per acre:

TABLE NO. 1

SUMMARY OF ALFALFA DUTY-OF-WATER INVESTIGATIONS AT DAVIS, 1910–1915

Number of irrigations	Unit depth each irrigation, in.	Depth of water applied, in.	Yield, tons per acre							Average value of hay per acre at $7 per ton[1]	Average cost of production per acre[2]	Average profit per acre
			1910	1911	1912	1913	1914	1915	Average			
None	....	....	3.85	5.94	5.52	2.75	2.89	2.35	3.88	$27.16	$8.73	$18.43
2	6	12	4.78	7.52	6.51	4.31	5.83	4.84	5.63	39.41	15.37	24.04
3	6	18	.....	.....	7.02	5.69	8.02	6.46	6.80	47.60	19.35	28.25
4	6	24	6.00	8.38	8.32	6.89	9.96	7.96	7.92	55.44	23.22	32.22
4	7½	30	7.53	9.54	9.43	7.97	11.06	8.32	8.98	62.86	26.45	36.41
4	9	36	7.58	9.33	9.38	8.22	12.48	8.63	9.27	64.89	27.96	36.93
4	12	48	8.45	9.52	8.63	8.83	10.62	8.05	9.02	63.14	29.10	34.04
4	15	60	.....	.....	10.17	7.25	10.70	5.55	8.42	58.94	29.44	29.50

[1] Market value of hay, 1910, 1911, and 1912, $11 per ton; 1913, $9; 1914, $4; 1915, $8.

[2] Labor of production, including cutting, raking, shocking, and hauling, figured at $2.25 per ton. Water figured at $1.70 per acre-foot. Labor for irrigation figured at 50 cents per acre per irrigation.

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Examination of this summary indicates that while both the average maximum yields and the average maximum profits were greatest in the case of annual applications of 36 acre-inches of irrigation water per acre, neither the average increase in yield nor the average increase in profits, with applications at the rate of 36 acre-inches per acre per year, over the average yields and profits with applications at the rate

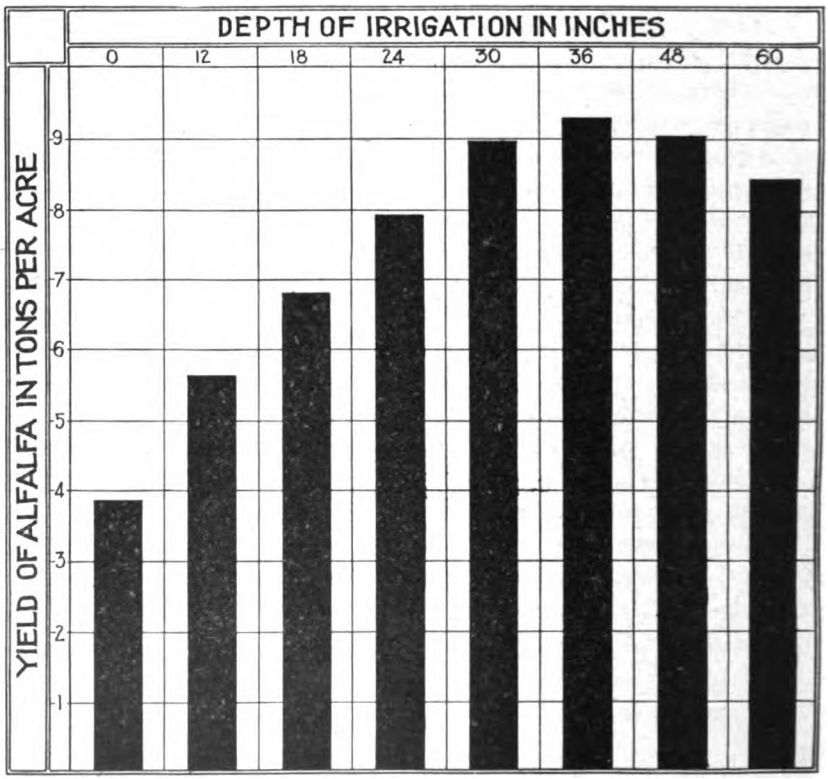

Fig. 1.—Diagram showing results of alfalfa duty of water experiments at University Farm, Davis, 1910 to 1915. Note the maximum yield with an annual application of 36 inches of water. The most economical yields were obtained with annual applications of 30 to 36 inches.

of 30 acre-inches per acre per year, was large enough to be material, with water costing at the rate figured in the Davis experiments. It is plain, however, that to the extent that water costs less than $1.70 per acre-foot the increase in net profits with annual depth of 36 inches over the figures for annual depths of 30 inches would be correspondingly greater, and very much greater if water were paid for at the

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flat annual rate of $1.50 or $2 per acre, as was the case in a number of the Sacramento Valley areas included in the general investigation.

The significant fact about the results at Davis is that the increase in yield tends to become negligible above annual depths of 30 to 36 inches, indicating that under conditions at Davis, or similar thereto, a maximum allowance of 36 acre-inches per acre per year is ample. This is further brought out graphically in the accompanying chart (fig. 1).

The most marked change from year to year in the relation of the averages to each other took place in the 60-inch applications. The 1912 yield from the most heavily irrigated plat was more than 10 tons per acre, but the average dropped to 8.42 tons per acre by 1915, and had the investigations been conducted longer this average doubtless would have decreased each year. The 1915 yield was only 5.55 tons per acre, owing to the quantity of rank water grass which had supplanted the alfalfa.

A wide variation in the seasonal rainfall and in the length of the growing season was observed at Davis. Both of these factors seemed to have a decided effect on the yields of hay, as shown by the following table:

TABLE NO. 2

RELATION OF CLIMATE TO YIELDS OF HAY AT DAVIS

Season	Rainfall	Length of growing season[1]		Average temperature, ° F.	Number of cuttings	Average yield of hay per acre from all checks
		Dates	Number of days			
1909–1910	11.90	Mar. 22–Oct. 10	202	57.7	6	6.36
1910–1911	23.18	Feb. 27–Oct. 7	222	58.3	6	8.37
1911–1912	9.46	Mar. 3–Oct. 10	221	57.9	6	8.12
1912–1913	8.74	Mar. 4–Sept. 17	197	58.0	5	6.49
1913–1914	28.70	Feb. 6–Oct. 26	262	60.0	6	8.94
1914–1915	20.05	Jan. 23–Oct. 13	263	59.5	6	6.52
Average	17.00	Feb. 23–Oct. 9	228	58.6		7.48

[1] Period between date of last killing frost in the spring and the date of cutting last crop the following fall.

Immediately following the harvesting of the last crop at Davis, on October 13, 1915, five areas, each containing 100 square feet, were laid off on each plat included in the experiment and the number of plants in each area counted. The probable number of plants per acre was figured from the average of these counts. By field count a good stand of mature alfalfa was found to contain an average of one and one-half plants per square foot. With this as a basis of comparison, the following table was compiled:

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TABLE NO. 3

ESTIMATED PER CENT OF ALFALFA STAND REMAINING AT DAVIS AT END OF SIX-YEAR EXPERIMENTAL PERIOD

Number of plats	Depth of water applied, in.	Number of plants per acre	Per cent of good stand remaining
17, 30	....	8,625	13.2
18, 29	12	22,216	34.0
19, 28	18	30,928	47.3
20, 27	24	33,977	52.0
21, 26	30	41,382	63.3
22, 25	36	39,422	60.3
23, 24	48	38,333	58.7
31	60	17,598	26.9

This shows the effects of the two extremes in the application of water, especially when it is remembered that the observations on the 60-inch application extended over a period of only four years, and in this time the stand, as a result of over-irrigation, was reduced to an estimated average of only 27 per cent of the original.

INVESTIGATIONS ON SACRAMENTO VALLEY ALFALFA FARMS

In selecting the areas away from Davis to be included in the wider investigation care was taken to include enough fields so that there would be represented the major soil types of the valley, as determined by the soil surveys of the Bureau of Soils and of the University of California Experiment Station, whose soil classifications have been followed in this report; also to give the investigations as wide a geographical distribution as possible, so that the differences in rainfall could be taken into consideration. Accordingly, during the irrigation seasons of 1913 and 1914, between 40 and 50 representative farms were under observation in the neighborhood of Gridley, Los Molinos, Orland, Willows, Woodland, and Dixon, this work being supplemented in 1915 by detailed studies on a single ten-acre tract five miles northeast of Willows, and by general observations and measurements on four other farms.

In every case where the amount of water used was measured the crop yields were ascertained by the most satisfactory means available. In some cases crops either were sold in bulk according to scale weights or baled, making exact weights available. In a few cases stacks were measured or a sufficient number of shocks to be representative of the whole were hauled to nearby scales and the average weight per shock obtained. In a large number of cases the average weight of shocks was ascertained by weighing on the ground.

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Table No. 4 below summarizes the results of the measurements on Sacramento Valley farms during 1913 and 1914.

TABLE NO. 4

SUMMARY OF RESULTS OF ALFALFA DUTY-OF-WATER MEASUREMENTS ON FIFTY-FOUR FARMS IN SACRAMENTO VALLEY, 1913 AND 1914

Name of area	Average rainfall, in.	Number of fields included	Areas covered by observations	Years	Average total depths of water applied, ft.	Average total yields, tons per acre
Gridley	22.24[1]	14	284.22	1913	3.31	6.19
Los Molinos	26.11[2]	12	130.40	1913–14	5.15	6.01
Orland	19.23	7	214.52	1913–14	4.66	6.26
Willows	16.55	3	27.71	1914	1.83	4.82
Woodland	17.23[3]	12	295.07	1913–14	2.33	6.45
Dixon	17.23[3]	6	207.17	1913	2.94	6.76
Totals and avgs.	19.76	54	1159.09		3.37	6.08

[1] Biggs record.
[2] Red Bluff record.
[3] Davis record.

If the amount of water used on Sacramento Valley farms, as indicated by the above table, were to be taken as the amount necessary to get maximum economic yield, it is evident that the results at Davis would not be applicable throughout the valley. The amounts of water applied, however, do not necessarily indicate the amounts needed. In many cases much more water was applied than was retained by the soil; and in the case of the compact soils about Willows it was not possible to get into the soil sufficient water to supply the needs of the crop. That the results at Davis are, in general, applicable throughout the valley, with the exception of the results on the highly pervious gravelly loams at Orland and the impervious Tehama clays and clay loams at Willows, was made plain from the approximately 11,000 soil-moisture determinations made on the Sacramento Valley alfalfa farms under observation during three years of the investigations.

At Davis the amounts of water used were strictly under control, and, with the exception of the plat receiving a depth of 60 inches, single irrigations were, as a rule, not greater than the soil would retain, the soil-moisture determinations before and after irrigation showing that an average of 76.4 per cent of the water applied to plats which were given a depth of 6 inches in one irrigation was retained in the upper 6 feet of the soil, and that the plats given 7½, 9, and 12 inches per irrigation, making an average of 9½ inches per application, retained an average of 60.6 per cent in the upper 6 feet of soil and 97.7 per cent in the upper 12 feet. The soil of the experimental irrigation tract at Davis is chiefly a fine sandy loam, relatively uniform, with no

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impervious stratum, and with the ground water level below the normal feeding zone of the plant roots. The upper two feet are very uniform, but the third to eighth feet are of fine sandy loam, pocketed at irregular intervals with coarse sand or clay loam. While at Gridley the surface soil of the fields under observation in 1913 does not vary greatly from the soil at Davis, most of it is underlaid with hardpan at depths of from four to six feet, and all of it contained free ground water at six feet or less from the surface. At Los Molinos, while the soil of some of the fields is comparable with that at Davis, being of silty or sandy loam and of relatively uniform depth for at least 12 feet from the surface, some fields have more clay and some are more gravelly than those at Davis. The normal rainfall at Red Bluff, which is the nearest point of observation to Los Molinos, is approximately nine inches greater than at Davis, and in the years 1913 and 1914 it was more than six inches above the average at Davis for the six years covered by the experiments there. An entirely different type of soil is found at Orland, all but one of the fields investigated having been made up largely of gravel. Here, also, water conditions differ considerably from those at Davis, a shortage of water in the late season in 1913 having made it necessary to eliminate one irrigation.

A very wide departure in soil type is encountered at Willows, and, as indicated by the summaries of use on fields under investigation there, it was impossible to get enough water into the soil to satisfy the needs of the crop. While the soils at Woodland are generally comparable with those at Davis, paying for irrigation water on a quantity basis rather than on an acreage basis, as at Gridley, Los Molinos, Orland, and Willows, altered the Woodland practice materially. During the season of 1913 at Woodland, following a winter of low rainfall, the usual practice was to give at least three irrigations, and some farms received water six times, alfalfa bringing good prices that year, and water therefore being applied plentifully. In 1914, however, following a winter of more than normal rainfall, and when the price of alfalfa had dropped to nearly one-third the figure obtainable in 1913, no irrigators watered more than three times, and as a rule only two, with many not watering at all. Observations were made at Dixon during 1913 only. Water used there is obtained from pumping plants and use generally represents what the various irrigators consider to be necessary. While in this regard conditions at Dixon are similar to those which governed the experiments at Davis, the soil is considerably heavier than at Davis, and takes water much less freely.

Gridley.—Analyzing the results obtained at Gridley, it was found that a maximum yield of 9.38 tons was obtained from a field which

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received a total annual depth of irrigation water of 31.6 inches, but that the next nearest yield was only 7.28 tons per acre, obtained on a field which received 34 inches of water for the season. Eight out of the fourteen fields studied at Gridley received greater annual depths of irrigation water than 34 inches, but on three of these the yield fell below five tons, on four below six tons per acre, and on seven below seven tons. In other words, after eliminating the single field that had the excessive yield of 9.38 tons per acre, it was found that the point beyond which it did not pay to add to the depths applied corresponds substantially with the points established in the Davis experiments, namely, between 30 and 36 inches. The seasonal rainfall at Gridley preceding the heaviest of these yields was 13.9 inches.

Los Molinos.—Analyzing the results obtained at Los Molinos for the seasons 1913 and 1914, it is found that a maximum yield of 8.31 tons per acre was obtained with a total annual application of 47.4 inches, following an average rainfall for the two seasons of approximately 24.4 inches. To what extent, if at all, excessive use here reduced yields by soil leaching can only be conjectured. Seven of the 11 fields under observation received more irrigation water than the field of maximum yield, the maximum application being 84 acre-inches per acre. Of these seven fields, however, one yielded less than four and one-half tons per acre, four below six tons per acre, and six below seven tons per acre. At Los Molinos it is to be noted that both the maximum and the majority of applications were considerably in excess of the applications at Davis, but, as pointed out in the discussion of soil-moisture determinations in this area, the soils of the Los Molinos fields are highly permeable and the use of water was wasteful. Studies of the underground distribution of the irrigation water applied showed that beyond a doubt large quantities passed below a depth of six feet, single applications amounting, in numerous cases, to between 20 and 30 inches.

Orland.—Averages for eight fields at Orland, where the soil is prevailingly gravelly, gave a maximum of 6.77 tons per acre, with a total annual application of 24.6 inches after an average seasonal rainfall of 19.2 inches. The maximum yield at Orland was obtained on the field that received the least water, the yield from two of the seven remaining fields falling below five tons, and that from five falling below six tons. Of the whole eight fields water was applied in excess of 80 inches on two fields, in excess of 55 inches on three fields, and in excess of 45 inches on five fields.

Willows.—With complete results available for only one year and from only three fields at Willows, but with these results verified by

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special studies in 1915, it is evident that the results are in no way comparable with the results at Davis, this being due to the "tightness" of the soil of the Willows fields and the impossibility of getting irrigation water into it in amounts sufficient to satisfy the plants. A maximum yield of only 5.39 tons was obtained at Willows with an application of 23.6 inches in addition to the seasonal rainfall of approximately 28.7 inches for the preceding winter. Results at Willows indicate plainly that the soil-moisture needs of alfalfa, on the soils that hold moisture so tenaciously as do those at Willows, are in excess of the maximum applications found in 1914. Further, it is plain from the special studies in 1915 that to irrigate adequately the silty clay loams and the clay adobes of the Willows area water must be applied frequently and in small quantities, and at no time following the winter rainfall must the soil be allowed to dry out. The amount of water used on these Tehama clay soils is sure to increase as improvement in their physical condition, due to cropping and cultivation, makes them more pervious to water.

Woodland.—Averages for the 12 fields at Woodland, for which full records are available, show a maximum yield of 8.81 tons per acre with a use of water of 29.7 inches in addition to an average seasonal rainfall of 18.3 inches. Three fields, which received depths of 23.5, 33.1, and 43.7 inches, gave respective yields of 7.60, 7.87, and 8.04 tons per acre. Taking seven fields for which the yields were most nearly equal, the range of variation being slightly over two tons and the average yield being 6.93 tons per acre, the average use was found to be a depth of 30.7 inches. Thus at Woodland it is found also that the usual maximum use, taking an average of one wet and one dry season, does not depart widely from that found most satisfactory at Davis; also that the maximum average yield for one field during the two years of record was obtained with slightly less than 30 inches.

Dixon.—Here the largest yield in the single year of observation was 9.97 tons per acre with a total depth of irrigation of 37.7 inches, in addition to a seasonal rainfall of 7.31 inches. The average use for six fields, from which complete records are available, was 35.3 inches, or again in close agreement with the Davis experiments.

The allowance necessary to be made for difference in local soil conditions and irrigation practice is, it is believed, fully established by the comparisons made above. In general, as already indicated, the statement is justified that the six-year record for Davis is applicable throughout the valley except to the very open soils such as those around Orland, and the silty clays and clay adobes found in these investigations in the neighborhood of Willows, but also existing else-

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where in considerable areas. The average for Willows indicates, as already pointed out, that total irrigations of less than 24 inches per season are insufficient for satisfactory yields, while the results at Orland indicate that applications averaging in excess of 48 inches per year, while sometimes difficult to overcome on the very gravelly soils, do not give corresponding increases in tonnage. The average use at Woodland, which was below that at either Dixon or Gridley, was plainly a result of paying for irrigation water on a quantity rather than on a flat acreage basis. Finally, the average at Gridley illustrates what may be expected on the open loam soils underlaid with hardpan or ground water.

INVESTIGATIONS ON EXPERIMENTAL TRACT AT WILLOWS

Investigations on alfalfa farms near Willows in 1913 and 1914 disclosed a relatively small use of irrigation water and correspondingly low yields of hay. Soil borings soon made it evident that irrigation water was not penetrating sufficiently deeply into the soil to meet the needs of the alfalfa plants. In some cases irrigators who considered that they were applying an ample quantity of water were in fact wetting only the upper ten or twelve inches of soil, whereas normally at least the upper four to six feet should have had water.

The heavy soils encountered in the investigations around Willows are classified in the soil survey as Tehama clay and clay loam.[3] These soils are all of compact structure and inclined to be refractory, very sticky when wet, and subject to hard baking when drying.

As indicated in table No. 4 above, the average use of water on three farms at Willows in 1914 was 1.83 acre-feet per acre, and the average yield on six farms there in 1914 was only 4.82 tons per acre. In no single case was more than 1.97 acre-feet of water per acre applied per season, and none of the measured yields of alfalfa exceeded 5.39 tons per acre.

For the purpose of ascertaining if more frequent irrigations would improve conditions on these heavy soils, a field of 8.75 acres about five miles northeast of Willows was utilized for experimental purposes during the season of 1915. This field was already in alfalfa and carried one of the best stands to be found in the immediate neighborhood. The field was divided into twenty-one border checks, 60 feet wide by 300 feet long, having an average grade of four inches per one hundred feet and an average area per check of 0.42 acre.

[3] U. S. Dept. Agr., Bureau of Soils, Reconnoissance Soil Survey of Sacramento Valley, California.

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The soil in this field, which is classed as a Tehama clay loam, is grayish in color and of compact structure and refractory nature. When wet it is sticky, and upon drying becomes very hard, but does not check or crack. It is free from both hardpan and gravel and little difference is noticeable between the soil and subsoil. This type of soil was selected because the soil survey maps indicate the presence of about 45,000 acres of it in the Sacramento Valley, very largely east of Willows in the area surrounding this field.

The amount of water used on each of the plats during the season was two acre-feet per acre, an average irrigation head of 2.82 cubic feet per second being generally divided between two checks, although various other sizes of heads were tried. One-third of the twelve checks under observation were irrigated with a depth of six inches, once for each cutting except the last, one-third received two three-inch irrigations between cuttings applied just before and just after the crop was removed, and one-third received three two-inch irrigations, at intervals of about 12 days. All of the water entering the field was measured by a 2½-foot rectangular weir and automatic register.

For the purpose of increasing, if possible, the perviousness of the soil to water, two checks were treated with ground limestone at the beginning of the season at the rate of four tons per acre. It was not expected that these checks would show much change the first year, and they did not. The largest annual yield of alfalfa, 5.07 tons per acre, was obtained from the checks receiving three two-inch irrigations per cutting, an increase of 18 per cent over the lowest yields, 4.42 tons per acre, being secured from the checks that received two three-inch irrigations per cutting, and lowest yield, 4.29 tons per acre, coming from the checks irrigated with one six-inch irrigation per cutting.

While the above increases of yield indicate the desirability of more than one irrigation per cutting, the differences in the one season of investigations were not great. It was evident to those in the field, however, that the more frequent the application of water the better the moisture condition of the soil. Borings for soil-moisture determinations were difficult, except immediately after irrigations, and even then difficulty was encountered below the first foot of soil. Including the 12 plats, a total of 3408 moisture determinations were made before and after irrigations, and while the chief value of these is in the larger understanding they give of the character of these compact soils, especially with reference to the permeability to irrigation water they substantiate, to the extent reasonably to be expected, the better results due from the more frequent applications of irrigation water.

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In order to gain an idea of the root development of the alfalfa in this field, a hole about six feet square and three feet deep was excavated. This also afforded a good view of the cross-section of the soil formation. The roots of the plants were carefully removed. It was found that the taproots of the alfalfa were not over one-half inch in diameter and did not extend below a depth of three feet. The main mass of the roots was concentrated in the upper two feet of soil. The fact that the greater part of the alfalfa plants in this particular field are shallow-rooted is attributed largely to the compact structure of the soil, making moisture penetration difficult.

After removing the soil for root examination some rather surprising results were found in tests made by filling the hole from which they came with water and noting the time required for downward and lateral percolation. Twenty-four hours after the hole had been filled to a depth of three feet there remained in the hole two feet of water. Two weeks later there still remained one foot. Holes two inches in diameter and four feet deep bored 12 inches away from the large test hole showed no lateral percolation. In holes bored six inches from the test hole a slight amount of water had seeped through after 12 hours. Later another hole was excavated in a different part of the field and similar trials made, practically the same results being secured as in the first test. These tests serve to show the impermeability and peculiar physical conditions of the soil represented in this field.

QUANTITIES OF WATER TO APPLY TO SACRAMENTO VALLEY ALFALFA FIELDS AT SINGLE IRRIGATIONS AS DETERMINED BY THE CAPACITY OF THE DIFFERENT SOILS TO RETAIN WATER

At the outset of the investigations, one of the important practical questions presented was, How much irrigation water applied at one time, and added to that already present in the soil at the time of irrigation, would the various soils of Sacramento Valley retain? While no particular effort was made in the investigations to ascertain how much irrigation water the various soils encountered would hold during the actual process of irrigation,[4] it was desired to ascertain how much would be retained after any surplus should pass through the soil; or, in other words, how much of the water applied would be retained against gravity. As the amount retained would depend largely upon the size of the soil particles, it was deemed best to have mechanical analyses made of the soil from a number of the fields under observation. This was done by the Division of Soil Technology of the

[4] This was however, indirectly ascertained through "pore space" determinations.

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College of Agriculture of the University of California. Further, as the quantity of water soils will absorb and the rapidity with which it is absorbed depend to a considerable degree on the compactness of the soil, and, in order to determine what portion of the water applied in irrigation was retained by the soil, it was necessary to ascertain the volume weight of the soils "in place." This was done partly by standard laboratory methods, but chiefly by a special field method devised in the course of the investigations, and found to conform within satisfactory limits to other methods commonly used by investigators in more precise experiments.[5]

The principal work in tracing the underground distribution of the irrigation water was done on fifteen fields—two at Gridley, four at Los Molinos, one at Orland, two at Willows, five at Woodland, and one at Dixon. With the possible exception of one of the fields at Woodland and the two fields at Willows, the soil sampling indicated that the capacity of the soil to retain water, assuming sufficient underdrainage to carry off the free water in the soil, was satisfied. A careful analysis of the results of the soil sampling and moisture determinations brings out the following facts that should be of practical interest to irrigators.

1. Four times as much water was applied, on the average, to the silt loam soils with fine sandy loam subsoils as it was possible to apply, on the average, to the compact clay soils of the experimental tract at Willows, and more than three times as much as was applied to the clay soils of two of the fields at Willows.

2. Only about one-third of the water applied to the silt loam soils, as represented by five fields, was retained for the use of the alfalfa plants in the upper six feet of the soil, where the principal root development is located.

3. In the case of none of the 15 fields under observation did the amount of water retained per irrigation in the upper six feet of soil exceed 8.20 acre-inches per acre,[6] and in only two cases of the 15 did it exceed six acre-inches.

[5] The method followed consisted in weighing all of the soil taken from holes carefully bored with a two-inch posthole type soil auger and then ascertaining the volume of this soil as it was "in place" by the use of a thin rubber tube inserted in the hole and filled with a known quantity of water. This method was "checked" against the laboratory method by use of the Bowman soil compactor, the iron cylinder, and the paraffin methods as applied to soils in place in a series of experiments conducted by Mr. O. W. Israelsen of this investigation and Professor Charles F. Shaw of the Division of Soil Technology of the College of Agriculture of the University of California.

[6] Clay loam strata at depths varying from eight to ten feet caused partial waterlogging in overlying soil, hence the figure 8.20 is unusually high. All of the water in this soil was not retained against gravity.

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4. In only two cases out of ten in connection with the clay soils did the water that was absorbed by the upper six feet of soil reach four acre-inches per acre, in only three cases did it exceed three acre-inches per acre, and in four cases it was less than two acre-inches per acre.

5. The average quantities of water retained per acre-foot of soil per irrigation were 0.92 acre-inch for the silt loams with fine sandy loam subsoils, 0.71 acre-inch for the silt loams without fine sandy loam subsoils, 0.58 acre-inch for the clay loams, and 0.37 acre-inch for the clays, not including the experimental tract at Willows, in every case less than one acre-inch per acre-foot of soil.

6. The maximum average quantities of water retained by the upper six feet of soil per acre-foot per irrigation were 1.02 acre-inches for the silt loams with fine sandy loam subsoils, 0.75 acre-inch[7] for the silt loams without fine sandy loam subsoils, 0.78 acre-inch for the clay loams, and 0.49 acre-inch for the clays.

7. Counting only the fields in which the full capacity of the soils to retain water against gravity was satisfied, i.e., all of the fields having loam soils except one field at Woodland, the average water retained per irrigation in the upper six feet of soil was 4.31 acre-inches per acre, or only 32.6 per cent of the average individual applications, and only 0.72 acre-inch per acre-foot of soil.

8. Assuming that in every case the surface foot of soil received at each irrigation sufficient water to satisfy its full capacity to retain water against gravity, it is found from the detailed data at hand that the average for the 18 fields, including the experimental tract at Willows, was 1.23 acre-inches per acre, and that the averages for the different soil types were 1.08 acre-inches per acre for the silt loams, 1.35 acre-inches per acre for the clay loams, and 1.35 acre-inches per acre for the clays. Therefore, in the case of the typical silt loam soils of the Sacramento Valley, assuming one irrigation per cutting, single applications of irrigation water exceeding a depth of one to one and one-half inches per foot in depth of the soil it is necessary to moisten, accomplish no useful purpose. The typical clay loams and clays of Sacramento Valley, in their normal condition of moisture, will absorb and hold against gravity as much as one and one-fourth to one and three-fourths inches in depth of irrigation water per foot of soil it is necessary to moisten; however, that amount of water will not be absorbed by these soils unless it is applied very slowly.[8]

[7] Not counting the field on which 8.20 acre-inches per acre were retained because of abnormal conditions previously referred to.

[8] It is of interest here to note that with the surface foot of soil filled to its capacity to retain water against gravity the percentages of the pore space of the soil filled were as follows: for the silty loam soils, from 37 to 55 and averaging

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It seems evident from the figures given above that there is much ground for improvement in the matter of the quantity of water to apply to the alfalfa fields of Sacramento Valley at single irrigations. Had it been feasible to carry the soil-moisture determinations to a greater depth than six feet, the extent of the waste resulting from the large single applications would be still clearer. The data obtained are, however, sufficient to show clearly that the prevailing practice on Sacramento Valley alfalfa fields is to apply far more water at single irrigations than the more open soils have capacity to retain and than the more compact clay soils absorb under methods of application followed.

A significant comparison can be made between the amounts of water retained by the soil in the case of the 15 typical Sacramento Valley alfalfa farms and the amounts retained in the case of six of the plats on the experimental tract at Davis, where the applications of water were under definite control. The average depth of water applied per irrigation to these six plats was 7.75 inches and the average quantity retained in the upper six feet of soil in the years 1913, 1914, and 1915 was 4.59 acre-inches per acre, or 66.8 per cent of the amount applied. On some of these plats, however, the borings for soil-moisture determinations were made to a depth of 12 feet, and it was found that within this depth practically all of the water applied was retained for the benefit of the plants. The average amount of water added by irrigation to the surface foot of soil in the Davis experiments was 1.45 acre-inches per acre. In other words, from the standpoint merely of the capacity of such deep loam soil as that at Davis to retain irrigation water against gravity, and assuming that the lower depths will "take up" as much water as the surface foot, the application once per cutting of one and one-half acre-inches of water per acre-foot, of soil it is desired to moisten, is not excessive.

DESIRABLE IRRIGATION "HEADS" FOR SACRAMENTO VALLEY ALFALFA FIELDS

In any investigation of the proper duty of water the size of the irrigation heads used and its relation to the type of soil irrigated, the method of irrigation followed, and the size and slope of the individual areas watered with a single head are always important. Fields may be evenly surfaced and levees perfectly made and proportioned, and yet the result will be excessive waste or inadequate absorption if the

45.5; for the clay loam soils, from 51 to 71 and averaging 62.2; for the clay soils, from 57 to 74 and averaging 65.5; and for all of the fields combined, 54.5.

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stream of water turned into each check is either too large or too small. The discussion as to what became of the water applied on a number of Sacramento Valley alfalfa fields, already presented, showed that where large quantities were applied to the open loam soils at single irrigations much of the water passed below the principal rooting zones of the alfalfa plants, and that the usual practice followed in irrigating the clay soils failed to accomplish sufficient penetration by the water. The stabilizing of the irrigation heads used in Sacramento Valley, with direct reference to the size of checks and the character of the soil,

Fig. 2.—A thoroughly prepared alfalfa field ready for final harrowing and seeding. These checks do not exceed 500 feet in length or 40 feet in width.

is obviously one of the very important irrigation problems of the valley. Quite extensive experiments and observations will be necessary for furnishing a satisfactory basis for fully understanding this problem, but the collection of some information bearing on the question was accomplished during the investigations in 1913 and 1914. This information was obtained from twenty-five fields—three at Gridley, two at Los Molinos, five at Orland, two at Willows, nine at Woodland, three at Davis, and one at Dixon. Five classes of soil were covered—gravelly loams, three fields; sandy loams, four fields; silt loams, nine fields; clay loams, six fields; and clays, five fields. Observations of the underground distribution of the water applied were made in connection with ten of the fields.

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From an investigation of the data gathered in these investigations, it is evident that the most desirable head of water to use on any given soil can not be adequately determined by comparing use on different fields. The present general practice in Sacramento Valley, expressed in cubic feet per second per acre, is, however, satisfactorily indicated from the average figures obtained, namely, 23 for gravelly loams, 10.9 for sandy loams, 8.8 for silt loams, 7.3 for clay loams, and 3.2 for clays. The difficulty of irrigating porous soils with small heads and of irrigating clay soils with large heads is well recognized among irrigators, even if the most satisfactory relationships have not been worked out in detail.

While a comparison of the rates of application on the different fields as given above fails to disclose the best size of head to use, a comparison of the relation between irrigation heads and depths of application on single fields makes it plain that in many cases either the head should be increased or, even better, the area of the checks reduced.

Summarizing the rates and depths of application at different irrigations of five individual fields, it was found, with minor exceptions, that in each instance, where the soil was sandy loam or silt loam, the depth of water applied increased as the rate of application decreased. In one case, due to the use of a relatively small head, a depth of 3.03 feet of irrigation water was used before the surface of the field was flooded. In four cases more than 2 feet in depth was applied per irrigation, and in fourteen cases out of twenty-seven the depth of application at each irrigation exceeded one foot.

In order to carry this matter further, measurements of the amount of water required to cover a one-acre check, having a slope of 3½ inches per one hundred feet, when applied at different rates were made at Davis. The data obtained were as follows:

Rate of application, cu. ft. per sec. per acre	Depth of water required, ft.
4.6	2.75
10.1	1.86
13.5	1.16
15.3	0.84
17.8	0.69

Until the proper relation between irrigating heads and size of checks is satisfactorily worked out in Sacramento Valley soil, there is sure to be, there as well as elsewhere, much difference of opinion as to whether small checks and correspondingly small irrigation heads or large checks and correspondingly large irrigation heads should

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prevail in the irrigation of alfalfa. Those who favor large checks and large heads base their preference chiefly on the greater rapidity with which irrigation can be accomplished with large heads, and also on the assumed lesser cost of preparing the land for irrigation. As a rule, where large heads are available they are used, and in some cases, as pointed out in connection with the heavy soils, especially the "watertight" soils found in some portions of the Willows area, the heads were plainly larger than they should be. In the case of individual pumping plants, which rarely discharge more than one or two cubic feet per second, checks necessarily are small. That waste of land goes with the large field ditches necessary in carrying large heads, and also that extravagant notions of use, and a greater waste when breaks occur with large heads, are sound arguments in favor of small heads, can not be doubted. Thoughtful consideration by irrigators and intelligent advice by public agencies in time will work out that relationship which best will serve both irrigators and the public. In the meantime, it is very clear that irrigators should bear in mind the fact that the irrigation head should not be a constant quantity, but should be varied, where practicable, with the different soils found on nearly every farm.

Dimensions and grades of alfalfa checks vary somewhat in the six sections of Sacramento Valley studied. Some square and rectangular checks are used in each section, but border or "strip" checks are most common, except on gravelly soils at Orland, where the most satisfactory check probably is one about 100 feet square, containing a little under one-fourth acre, and with each check having direct access to a field lateral to do away with carrying water to one check over another. The border checks range from 30 to 120 feet in width and from 60 to 1750 feet in length, the most usual width being from 30 to 50 feet and the most usual length from 400 to 700 feet. The grades of border checks range from 0.6 to 12 inches per 100 feet and average 3.6 inches per 100 feet.

DESIRABLE MOISTURE PERCENTAGES FOR ALFALFA IN SACRAMENTO VALLEY SOILS AND THE EFFECT OF VARIATION IN SOIL MOISTURE ON RATES OF ALFALFA GROWTH

In interpreting the results of the large number of soil-moisture determinations made at Davis and on Sacramento Valley alfalfa farms from 1913 to 1915, account has been taken of the moisture percentages found as related to the percentages at which the plants would wilt, and

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also of the effect of the variation in those percentages on the growth of the alfalfa. The percentages at which the plants wilt, or the "wilting coefficients," have been computed on the basis of the experiments of Messrs. Briggs and Shantz of the Bureau of Plant Industry of the United States Department of Agriculture.[9] As indicated by these experiments, the wilting percentage may be stated to be the point below which moisture in the soil ceases to be available to the plants, or, at least, below which it is obtained only with great difficulty. Due largely to the difference in the size of the soil particles, plants will wilt in clay soils when there is still an amount of moisture that in sandy soils would be ample for all plant requirements.

Determination of the wilting percentage of the soil was made for eight of the experimental plats at Davis, six of the experimental plats at Willows, and eleven of the Sacramento Valley alfalfa farms. Grouping the figures obtained, by soils, the average wilting percentages found were as follows: silt loams with fine sandy loam subsoils, 10.65; other silt loams, 13.12; clay loams, 14.21; clays, 13.06.

In other words, it is necessary that at least the percentages of moisture indicated shall be present in these soils at all times in the growing season if the plants are to be kept from wilting.

It must be noted, however, that in addition to these percentages of soil moisture that are necessary to prevent wilting, additional quantities must be present in order to produce satisfactory growth. Such additional amounts constitute the "available" moisture present in the soil.

Obviously, it is impossible to disregard the numerous soil and climatic factors other than soil moisture that affect the yields of alfalfa, and then to expect the yields and moisture percentages to be consistent throughout. However, by grouping the yields above eight tons per acre, from six tons to eight tons per acre, and below six tons per acre, it is possible to approximate the best or "optimum" percentage of available moisture over and above the amount necessary in each soil to prevent wilting.

Assuming the yields over six tons per acre to have been produced on soil having at least as much as the "optimum" percentage of available moisture, the data indicate that the "optimum" for Sacramento

[9] U. S. Dept. Agr., Bureau of Plant Industry Bulletin 230. The wilting percentages, or "wilting coefficients," for the Sacramento Valley soils are based on the "moisture equivalents" of those soils, as determined in the laboratory of the Division of Soil Technology of the College of Agriculture of the University of California in the course of these investigations. It might be noted here that the moisture equivalents are the percentages of moisture retained in the soil after the soil has been subjected to a centrifugal force equal to 1000 times the force of gravity.

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Valley conditions ranges between about 3 per cent and about 7 per cent and averages about 5 per cent above the wilting percentage.

For one of the fields at Los Molinos and one of the plats at Davis, on both of which an excess of irrigation water was applied, the average available percentage was 8.91, or well above the "optimum". On the other hand, the average percentage of available moisture on six experimental plats at Willows, four plats at Davis, one field at Woodland, and one field at Willows, for which either the application or the absorption of irrigation water was plainly deficient, was only 1.02, or well below the "optimum".

The percentages of moisture that must be present in the various Sacramento Valley soils dealt with in order to prevent wilting are believed to be of value because they indicate to Sacramento Valley irrigators not only the difference between the clay or "heavy" soils and the loams and sandy soils as regards the amount of soil moisture needed to prevent wilting, but also that for all of the soils the wilting percentage is higher than farmers usually suppose.

If one could assume an absolutely dry soil it might be convenient for irrigators to know that, as disclosed in the investigations, the amount of water necessary to supply the wilting percentage is approximately the equivalent of about one and two-thirds inches of rainfall per foot of depth of soil in which the crop is growing, in the case of the silt loams with fine sandy loam subsoils, of about two inches in the case of the other silt loams, of about two and one-fourth inches in the case of the clay loams, and of two and three-fourths inches or more in the case of clays such as those found at Willows.[10]

In other words, with an absolutely dry silt loam soil eight feet deep the first 16 inches of irrigation water would no more than supply the amount of moisture necessary to keep deep-rooting plants from wilting; or, expressed still differently, with such a soil wholly devoid of moisture, the equivalent of a rainfall of two inches for each one foot depth of soil the crop utilizes would need to be supplied before the roots of the crop could begin to utilize the moisture.

Fortunately an absolutely dry soil is rarely found in the Sacramento Valley, even at the end of the summer season, and except in very dry years the soils of the valley are not likely to begin the spring growing-season with less soil moisture than the wilting percentage.

[10] The soil-moisture studies in connection with the clay soils at Willows disclosed lower wilting percentages and lower capacities to absorb irrigation water than were to have been expected. It is not intended to discuss this technical phase of the subject in the present report, and conclusions for all Sacramento Valley clay soils can not and should not be drawn from the experience reported herein with the Tehama clays under investigation at Willows.

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The figures given should make it very plain that soils into which irrigation water percolates with difficulty should be watched very carefully at depths from four to six feet below the surface. The experience of the field investigators at Willows indicated that this care is especially necessary even early in the summer in order to insure that an adequate irrigation supply shall replace the moisture absorbed from the winter rainfall after that has been utilized.[11]

[11] What is said in the text regarding desirable moisture percentages for Sacramento Valley soils growing alfalfa considers the matter only from the standpoint of the total annual yields of hay. It is obvious, however, that the annual yields are results of conditions that vary from day to day and from week to week. For instance, considering the moisture factor only, annual differences in yield were results of the daily and weekly differences due to daily and weekly variations in soil moisture. The data collected have been studied with reference to the effect of these changing moisture percentages on the seasonal rates of growth, but as no data were collected to indicate daily or even weekly variations in rates of growth, making it necessary to rely on average rates of growth between cuttings, such deductions as were suggested in the study have not seemed sufficiently conclusive to warrant their presentation. It is, however, possible to say that where the moisture percentage was found to fall below the wilting point there was also found a definite falling off in the rate of alfalfa growth.

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SOME OBSERVATIONS ON THE BULK HANDLING OF GRAIN FOR CALIFORNIA

BY B. H. CROCHERON AND C. J. WILLIAMS

The method of handling grain in California has not changed in the last twenty-five years, despite the change in shipping conditions. As yet, practically all grain is sacked in the field and is so handled and shipped.

The present agitation for the bulk-handling of grain is not the first time that the question has been broached in California. Some twenty-five or thirty years ago, when California was a great wheat-exporting state, the millers attempted to bring about a change from the sack to the bulk system of handling grain. At that time practically all grain exported from California was shipped in sailing vessels going through the Straits of Magellan. Because of the length and tempestuousness of the voyage, there was great danger of the shifting of the cargo with the ultimate loss of the ship. When a ship carrying bulk grain lists, thus displacing the center of gravity, the cargo shifts with it, unless special devices are provided. Due to the shifting of their cargoes, several ships carrying bulk grain were lost en route to England. On account of the great risk, insurance agents refused to insure ships or their bulk cargoes, and as a result bulk-cargo shipping was ended.

Today, however, shipping conditions have changed. There are now few sailing vessels leaving our harbors, these having been replaced by modern steamers which are faster, safer and more reliable. Perhaps the greatest change, however, is that the route has been greatly shortened. It formerly required seventy-five days for a steamship to travel from San Francisco to Liverpool around South America. Today, with the use of the Panama Canal, the voyage can be made in thirty-five days, and by so doing practically all of the dangerous storm zone is eliminated. The change in shipping facilities and the shortening of the route to the markets of Europe has made bulk-shipping as practical from our western ports as from any other ports in the world.

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Since the last great agitation for the bulk-handling of grain, an enormous change has also been wrought in the grain production of California. Formerly wheat was the great grain crop; now barley has, to a large degree, taken its place in production. Formerly wheat was exported in large quantities; now wheat of higher gluten content is imported from the middle West to blend with our California wheats in order to improve the baking quality in manufactured flour. Barley, however, is exported, and therefore the export situation chiefly concerns itself with the handling of barley, either by the present sack method or by the proposed plan of bulk grain.

But handling conditions which applied to wheat may not apply with equal force to barley. Brewers buy barley largely on its physical appearance, rather than upon its chemical composition; thus bright, clear barley is valued at a higher price than discolored grain, even though the latter may have as good qualities for brewing. The custom of this trade, as in many other trades, must have a determinant effect upon the plan of handling the grain.

Thus, the kind of grain grown as well as the destination of the grain, whether for home or foreign consumption, has an important bearing upon the way in which it may best be handled in this state.

Grain-Shipping Conditions of the World.

The large wheat-producing countries of the world are today either handling their grain in bulk or changing over to the bulk system. Russia, which is one of the oldest grain exporting countries, not only handles all of her grain in bulk on the mainland, but also exports most of her foreign shipments in bulk cargoes. Australia, which is situated further than California from the markets of the world and which has been handling and shipping her grain in sacks for as many years as California, is now maturing plans by which the government will build elevators so that farmers may ship their grain by the cheaper bulk method. In Argentina, the government is making arrangements to change their system of handling wheat from the sack to the bulk method. These changes are there made possible through the use of modern steamships instead of the less reliable sailing vessels.

On this continent, Canada has recently done away with the use of sacks. Practically all of the Canadian wheat is transported in bulk through the country elevators, most of which are "farmers' co-operative," to the large terminal elevators built by the Dominion government and the great railroads. Most of the Canadian grain is exported from the Atlantic coast.

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There have been several elevators built in Washington and Oregon during the last few years. The Port of Seattle has just completed the construction of a 500,000-bushel elevator which is equipped for handling both sacked and bulk grain. At present about 10 per cent of the grain of Washington and Oregon is handled in bulk.

Almost all the United States handles and ships grain by bulk. In all the states east of the Rocky Mountains, the use of sacks in the manner common to California has never been known. Some few of the small farmers handle their grain in sacks, but this is not general. When used at all, sacks are of cotton and of a size larger than ours. Such sacks are used only in handling the grain on the farm and in transporting it to the local elevators, where the sacks are emptied and carried back to the farm to be refilled. All grain from the North Atlantic Coast to the Gulf is shipped in bulk on the steamers. The risk is taken by the ship-owners, or the insurance companies are paid to do so.

California Grain Distribution

The amount of barley exported from the Port of San Francisco has been steadily increasing for many years until 1914. In 1915 a slight decrease was experienced, due to war conditions.

It is estimated that the home consumption of barley is about 30,000 tons per month or 7,200,000 centrals per year. This is about one-third of the barley produced in California, while two-thirds is shipped elsewhere.

Changes Made Necessary by a Bulk-Handling System.

In California grain is generally harvested by the combined harvester which, traveling by animal or tractor power, heads the standing grain, threshes it and spouts it into sacks which are then sewn and left in the field. Only in a few sections of California is grain harvested with a binder and later threshed. The sacks from the harvester often remain where they are thrown for some days or weeks; later they are gathered into a pile under a tree or in a fence corner, where they remain for some time. Still later, at a convenient time, the sacks are hauled to a local warehouse on a railroad or steamboat line, from whence they take their course onward to a central warehouse. There the sacks are opened, the grain cleaned, the broken sacks replaced, the grain again sacked and then shipped to its destination in Europe or elsewhere.

Changing from the sacked to the bulk method of handling would entail: (1*a*) Equipping the combined harvesters in use with a spouting

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apparatus whereby grain from the harvester would be spouted directly into a tight wagon box, or (1*b*) equipping the combined harvesters in use with a bin on the side which would hold approximately one wagon load of grain, to be emptied into wagons as they pull alongside, or (1*c*) changing from the combined harvester to the self-binder. It would also entail on the farm: (2) the erection of grain bins or small tank elevators for storage of bulk grain until it is desired to transport the grain by wagon to the railroad. In places where farms are close to the railroad such bins or tanks may not be necessary. At the local railroad or water-shipping point where grain is received or shipped, there would be required: (3*a*) the erection of local elevators, or (3*b*) the refitting of existing warehouses to handle grain in bulk by bins, bucket belts and belt conveyors. At a central warehouse terminal, such as Port Costa, Sacramento, etc., there must be erected: (4) elevators to hold large amounts of grain for shipping. Further, for export grain (5) ships must be equipped to handle bulk grain by means of shifting boards.

The problem of changing from the sack to the bulk-handling of grain therefore not only depends for its solution upon the co-operation of the farmers, but also upon warehousemen, railroads, grain dealers and shipping companies.

The present investigation attempted to gather data and opinions from the staff of the College of Agriculture and other interested persons concerning the comparative direct expense of harvesting grain in bulk and in sacks, both from the combined harvester and from the self-binder. The investigation also attempted to set forth clearly the various factors that concern the practicability of the bulk-handling of grain. Some of these factors which concern warehousemen, shippers, etc., are outside the range of this study and therefore no attempt has been made to draw conclusions upon such points. However, men occupied in the business of grain handling and shipping have been consulted and their opinions are set forth herewith.

Owing to the varying size of fields and farms, of yields and crops, and the varying effectiveness of men and machines, but a very relative estimate of costs can be made. Therefore whatever estimates might be presented, critics would arise to pronounce them incorrect. The attempt has been made, however, to present average conditions, with the hope of stating figures that may be comparable. It is clearly understood by the investigators that under actual field conditions throughout the state there may be a wide variation from the costs as herein given. The figures and costs were obtained from the University

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of California Agronomy Division, farmers, and the observations of the investigators during several years' experience in the harvest fields.

Cost of Harvesting with the Combined Harvester and Sacking the Grain.

Yields of grain in California vary widely. Barley runs from 50 sacks to the acre to 10 sacks, a 15-sack yield is a fair average. Some grain, especially wheat, is cut at 6-sacks yield, and taking both wheat and barley into consideration 10 sacks is an average on which calculation may be based. The cost of harvesting with the combined harvester, which is the most widely used harvesting machine in the state, varies from $1.50 to $5.00 per acre for contract cutting, with $2.50 per acre as a good average. These prices do not include the cost of board of men and teams, nor the cost of sacks. The wide variation is due to the types of soil, the surface, topography and size of the field, the condition of the grain, whether upright or lodged, clean or weedy, and the degree of humidity in the locality, which determines the length of the working day. The amount of competition among the contractors in a certain locality is also an important factor. The cost of sacks has ranged from 6½c to 14c apiece for the last five years, with an average cost to the farmer of 8½c. The cost of twine varies with the amount used, which depends upon the yield. The cost of picking up sacks is variable, but 20c an acre is a good average. This allows $6.00 a day for a man, team and wagon for picking up 600 sacks a day. One man can pick up 500 sacks of wheat or 600 sacks of barley in a day and pile them in the field. Such a man commands a wage of $3.00 a day and board.

Harvesting with a combined harvester with the use of sacks, the cost will run for a

25-sack Crop—

Cost of combined harvester, per acre	$2.50
Cost of sacks, 25 @ 8½c	2.12½
Cost of twine	.08
Cost of picking up sacks, hauling ¼ mile and piling them in the field	.25
Total cost	$4.95½

10-sack Crop—

Cost of combined harvester, per acre	$2.50
Cost of sacks, 10 @ 8½c	.85
Cost of twine	.05
Cost of picking up sacks, hauling ¼ mile and piling them in the field	.20
Total cost	$3.60

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6-sack Crop—

Cost of combined harvester, per acre	$2.50
Cost of sacks, 6 @ 8½c	.51
Cost of twine	.05
Cost of picking up sacks, hauling ½ mile and piling them in the field	.20
Total cost	$3.26

Cost of Harvesting with a Combined Harvester and Handling the Grain in Bulk.

The handling of grain in bulk from the combined harvester is entirely practicable and is practiced in Washington, Oregon, Oklahoma and Kansas. In order to sell their harvesters in Kansas and Oklahoma, where the farmers are not accustomed to the use of sacks, one of the manufacturing companies has a bulk attachment which it puts on its machines, enabling the owner to take the grain from the machine in bulk. Where the elevator is coming into use in Washington and Oregon and the combined harvester is used, many bulk attachments are sold for the bulk-handling of grain. The Ramina Ranch of Tehachapi, Kern County of this state, uses a bulk attachment on a combined harvester in harvesting wheat. In bulk-harvesting the combined harvester spouts the grain directly into a wagon box or the harvester is equipped with bin and elevator attachment which will carry from five to ten sacks of grain.

The bulk attachment usually consists of a grain auger, a bin which holds from five to ten sacks, depending on the size of the harvester, and a cup conveyor which carries the grain from the bin into the wagon. It works very satisfactorily on level ground, but a great deal of trouble is likely to be experienced on side hills, where it will be practically as hard to keep the wagon under the elevator spout as it used to be to keep the old header wagon under the header spout. On many side hills, the header wagon had to be tied to the header spout to avoid losing the grain. This would be impossible with a grain wagon.

Where the grain wagon is impracticable a few good sacks can be bought and filled. They can then be hauled to the elevator and emptied and returned again to the farm where they can be refilled. This is practiced to a great extent among the small farmers of the East. A 120-pound cotton sack is used, which with good care will last two or three years.

Where a harvester is threshing a large crop of 80 sacks per hour, which would be about a 25-sack crop, there would be two loads of 40 sacks each an hour. The average rate of travel of a team under load is two and one-half miles per hour. Figuring one-half hour to load

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we can tabulate the time of the haul and the number of wagons required for the unit distance. Also, taking 30 acres a day as our standard and $6 as the cost of each wagon, we can figure out the cost of hauling per acre for the unit distances.

Number of wagons	Cost per acre	Distance-miles (round trip)	Time of haul (hours)
3	$0.60	2	1
4	.80	4	2
5	1.00	6	2¾
6	1.20	8	3½
8	1.60	10	4½
9	1.80	12	5½

The cost of hauling more than a 12-mile trip becomes prohibitive, as the grain could be sacked and hauled as cheaply or, for the cost of hauling, bins could be built by which the grain could be handled much more conveniently.

In handling grain in bulk on most of our California ranches, perhaps the most practical method would be to haul the grain from the harvester to bins on the ranch. This is being practiced more and more in the East, due mostly to the manufacture of light, portable, steel bins which can be conveniently located about the field and which only cost 12c to 15c a bushel capacity to build. Also the scarcity of labor at harvest time and the independence of the farmer in holding his grain in his own bins has made their use popular. There are many firms in the East who manufacture these steel bins, which hold from 1000 to 2000 bushels. Stationary bins are made which hold up to 4500 bushels. Wooden crib bins cost about 15c to 20c per bushel capacity to build. Machinery and gasoline motor for filling these bins can be purchased for from $150 to $200.

The figures here given contemplate the storage of the grain in bins on the ranch because of the great variation in the distance of hauling from different ranches. In figuring the cost of harvesting with a combined harvester and handling the grain in bulk, 25c per acre is deducted from the usual cost of the harvester per acre. This amount is saved by elimination of the sack sewer and tender, or "jigger."

Harvesting with a combined harvester and handling the grain in bulk the cost will run for a

25-sack Crop—

Cost of combined harvester, per acre	$2.25
Cost of hauling with three wagons, hauling ½ mile and unloading	.60
Total cost, per acre	$2.85

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10-sack Crop—

Cost of combined harvester, per acre	$2.25
Cost of hauling ½ mile and unloading with two wagons	.40
Total cost, per acre	$2.65

6-sack Crop—

Cost of combined harvester, per acre	$2.25
Cosh of hauling ½ mile and unloading with one wagon	.20
Total cost, per acre	$2.45

From the above tables it appears that the extra expense of sacking grain with a combined harvester is:

Cost of harvesting 25-sack crop with sacks	$4.95½
Cost of harvesting 25-sack crop without sacks	2.85
Extra expense of sacking, per acre	$2.10½
Cost of harvesting 10-sack crop with sacks	$3.60
Cost of harvesting 10-sack crop without sacks	2.65
Extra expense of sacking, per acre	$0.95
Cost of harvesting 6-sack crop with sacks	$3.26
Cost of harvesting 6-sack crop without sacks	2.45
Extra expense of sacking, per acre	$0.81

Cost of Harvesting with a Binder and Stationary Thrasher with Sacks.

The cost of binding varies from 50c to $1.00 per acre, with 75c as a good average. The average cost of binder twine is 35c per acre. Thrashing with a stationary thrasher varies from 10c to 14c per 110 pounds. In thrashing grain with a stationary thrasher, and handling grain in bulk, but 11c per 100 pounds is charged. No wagons are figured as the grain is carried directly from the stationary into portable bins.

Harvesting with a binder and stationary thrasher with sacks, the cost will run for a

25-sack Crop—

Cost of sack twine	$0.08
Cost of binder twine	.35
Cost of binding, per acre	.75
Cost of hauling bundles, per acre	1.00
Cost of sacks, 25 @ 8½c	2.12½
Cost of thrashing, 2500 lbs. at 12c per 100 lbs.	3.00
Total cost, per acre	$7.30½

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10-sack Crop—

Cost of sack twine	$0.05
Cost of binder twine	.35
Cost of binding, per acre	.75
Cost of hauling bundles, per acre	1.00
Cost of sacks, 10 @ 8½c	.85
Cost of thrashing, 1000 lbs. @ 12c per 100 lbs.	1.20
Total cost, per acre	$4.20

6-sack Crop—

Cost of sack twine	$0.05
Cost of binder twine	.35
Cost of binding, per acre	.75
Cost of hauling bundles, per acre	1.00
Cost of sacks, 6 @ 8½c	.51
Cost of thrashing, 600 lbs. @ 12c per acre	.72
Total cost, per acre	$3.38

(The cost of thrashing a 6-sack crop would probably be more than 12c per 100 lbs.)

Cost of Harvesting with a Binder and Stationary Thrasher and Handling the Grain in Bulk.

Harvesting with a binder and stationary thrasher and handling the grain in bulk, the cost will run for a

25-sack Crop—

Cost of binder twine	$0.35
Cost of binding, per acre	.75
Cost of hauling bundles, per acre	1.00
Cost of thrashing, 2500 lbs. @ 11c per 100 lbs.	2.75
Total cost, per acre	$4.85

10-sack Crop—

Cost of binder twine	$0.35
Cost of binding, per acre	.75
Cost of hauling bundles, per acre	1.00
Cost of thrashing, 1000 lbs. @ 11c per 100 lbs.	1.10
Total cost, per acre	$3.20

6-sack Crop—

Cost of binder twine	$0.35
Cost of binding, per acre	.75
Cost of hauling bundles, per acre	1.00
Cost of thrashing, 600 lbs. @ 11c per 100 lbs.	.66
Total cost, per acre	$2.76

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From the above tables it appears that the extra expense of sacking grain with a binder and stationary thrasher is:

Cost of harvesting by the self-binder a 25-sack crop with sacks	$7.30½
Cost of harvesting by the selfbinder a 25-sack crop without sacks	4.85
Cost of sacking a 25-sack crop, per acre	$2.45½
Cost of harvesting by the self-binder a 10-sack crop with sacks	$4.20
Cost of harvesting by the self-binder a 10-sack crop without sacks	3.20
Cost of sacking a 10-sack crop, per acre	$1.00
Cost of harvesting by the self-binder a 6-sack crop with sacks	$3.38
Cost of harvesting by the self-binder a 6-sack crop without sacks	2.76
Cost of sacking a 6-sack crop, per acre	$0.62

It can be noted from the above figures that the cost of sacks and twine and the wages of the sack sewer and tender are the controlling factors in the cost of sacking grain. However, under most conditions on the Pacific Coast, bulk grain brings a lower price for export than sacked, the price of sacks being deducted for bulk grain. If this remains the custom the saving of bulk-harvesting will be largely eliminated.

It is also true that much of the barley retained in the state is sold for feed in sacks, and probably will always be thus sold. Hence it will probably always be necessary to use sacks for that portion of the crop which is consumed at home.

Comparative Costs per Acre of Four Methods of Harvesting.

	Yield of 25 sacks	Yield of 10 sacks	Yield of 6 sacks
Combined harvester with sacks	$4.95	$3.60	$3.26
Combined harvester in bulk	2.85	2.65	2.45
Self-binder with sacks	7.30	4.20	3.38
Self-binder in bulk	4.85	3.20	2.76

Reviewing the above figures it will be noted that there is a decided saving in handling grain by bulk over that in sacks, *provided* the same harvesting machine is used as before. It is evident, however, that the harvesting costs of the combined harvester with sacks and the self-binder with bulk grain are about equal. Therefore, if along with the elimination of sacks, the "binder" is to supplant the "combine," the saving to the farmer must come from other superiorities that the binder has over the harvester and which bulk grain has over sacked. These superiorities have been claimed to be:

(1) Decreased cost in handling bulk grain *after* it is harvested;
(2) Decreased amount of grain lost by bulk handling;

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(3) Decreased amount of grain lost in the field by the binders;
(4) Decreased depreciation on machinery;
(5) An improved quality of grain through decrease in weediness.

The three latter factors are contingent wholly upon the use of the binder and are therefore outside the scope of the present investigation. Only the first two points will be here considered.

Decreased Cost in Handling Bulk Grain after It is Harvested.

(1) *Cost of Handling Sacked Grain after Harvesting*

The cost of handling sacked grain is divided into four stages: (*a*) from the machine to the pile in the field and protection there until hauled, (*b*) to the country warehouse, (*c*) the country warehouse and (*d*) the terminal warehouse.

(*a*) Cost from the machine to the pile and covering the pile with straw to protect it from sunburn varies with the size of the crop, but we can figure 30 tons of grain as a good day's work for one man and team.

Cost of man, team and wagon, per 30 tons	$6.00
Cost of handling from field to pile, per ton 6/30	$0.20
Cost of covering pile with straw, per ton	.05
Total cost of piling and covering, per ton	$0.25

(*b*) The cost of hauling from the pile to the warehouse at the railroad varies a great deal with the distance of the haul and conditions of the roads, but we can figure that the wagons can be loaded and that ten mules will haul eight tons and travel twenty miles per day. This is the general method of hauling grain from the large ranches in California. The cost of such an outfit is:

Wages of man	$3.00
Hire of mules, 5 span @ $1.50 per span	7.50
Rent of three wagons	1.50
Total cost per day for 8 tons	$12.00
Cost of hauling a ton 10 miles and return	1.50

This cost to some may seem a high average, but it is believed, in most cases, will be found rather low than otherwise. The cost of hauling a shorter distance where two trips could be made a day would, of course, be much less. The only additional cost would be the hiring of a swamper for $2.50 per day. Then the total cost of handling sixteen tons would be but $14.50, or 86c per ton. Where the distance is short from the farm to the warehouse, the farmer often furnishes a man with a team and wagon and pays him from 1c to 2c a sack, depending

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on the haul, for picking up the sacks and hauling them to the warehouse.

(*c*) Country warehouse charges as regularly fixed by the Railroad Commission are 75c per ton. This covers the weighing, piling and loading into cars and storage for two months.

(*d*) No definite figure is obtainable of the cost of handling sacked grain at the terminal warehouses, due to the variations in the amount of grain that is handled at different times. This is one of the greatest difficulties with the warehouse system. So much of the work must be done by hand labor that it requires a large number of men. It is practically impossible to keep all these at work all of the time, because of the fluctuation in the daily amount of grain that comes in and leaves the warehouse.

Mr. E. J. Luke of the Sperry Flour Company at Stockton states that it takes 14 to 18 men from 36 to 48 hours, according to tide conditions, to unload a 500-ton barge of sacked grain, with the following cost: 10c per ton taking it from barge, weighing it and putting it into warehouse, 25c a ton to take it from scales, pile it up, pull it down and truck it over to mill dump, making a total cost of 35c per ton to handle it this way.

Mr. McLean of the Globe Milling Company states that it required 35 stevedores and 10 of their own men 5 days of 10 hours to unload a 3000-ton ship. This cost amounts to about 35c a ton in wages.

Some of the operations that must be performed in bringing the sacked grain in and sending it out at some of the big Port Costa warehouses are as follows: The cars are unloaded by hand, the number of men required to do the unloading varies according to the distance of the trucking; but it is usually figured to unload one car an hour. The grain is piled as it is brought in after weighing. There are pilers, machine feeders and a foreman for the entire crew. When the grain is shipped out it must be taken down from the pile, put on a conveyor and carried to the cleaner. Here the sacks are cut open and run through the cleaner. After cleaning the grain is bagged, put on conveyors and carried to the ship or car. A sampler samples each sack and also each sack is marked on the way to the ship. This entire operation requires a large gang of men, consisting of markers, samplers, weighers, sack counters, sack cutters, truckers and carrier feeders. Besides these men there are stevedores in the hold of the ship and on the outside feeding the ship's carriers. A great many of the broken sacks must be patched and some men are kept busy at this work. About 15 per cent of the grain shipped has to be resacked. Several

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machinists and mechanics work about the cleaner and conveyors. All these men receive high wages.

The Port of Seattle gives the following rates for the handling of sacked grain at their terminal warehouse, which would correspond very closely with ours:

Unloading cars, piling outward, wharfage and 60 days storage	$0.50
Trucking to ship, per ton	.12½
Cost of resacking, per ton	.30
Cost of sacks, per ton, to replace old ones	.24
Cost of twine	.05
Cleaning and weighing, per ton	.40
Cost of loading ship	.05
	$1.66½

Summing up the cost per ton for handling sacked grain after harvesting:

Cost from farm to warehouse	$1.50
Cost at country warehouse	.75
Cost at terminal warehouse	1.66½
Total cost, per ton	$3.91½
Total cost, per 100 lbs.	.185

(2) *Cost of Handling Bulk Grain after Harvesting*

Because of the small amount of grain that is handled in bulk in this state, it is impossible to obtain any definite figures on the cost of handling it. On the farm, the cost of handling bulk grain is a little more than that of handling sacked grain, because of the number of wagons required to haul it from the machine to the bins. With a stationary thrasher where the grain is run directly into the bins from the thrasher, the cost is much less for handling it than with sacked grain. As to the cost of hauling bulk grain from the farm to the country elevator, although the length of the haul is as great, the time of loading and unloading is decreased and may permit the employment of a cheaper man or a boy. Bulk-handling saves a lot of hard work. This is difficult to figure in dollars and cents and therefore for our purpose we will consider the cost as about $1.50 per ton.

The only information that we have available in California on the cost of handling bulk grain is obtained from the milling companies. Mr. Luke of the Sperry Flour Company states that on unloading a barge load of 500 tons of bulk wheat the cost is less than 4c per ton from the barge to the mill bins, and the difference in weight on the bulk wheat averages about 300 pounds on each barge load of 500 tons.

Mr. McLean of the Globe Milling Company of San Francisco says that by handling their grain in bulk on their bulk-carrying steamer

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Portland from Portland to San Francisco, they pay for the operating charges, depreciation and interest (not including insurance) on $200,000, the cost of their 3000-ton vessel, for 60c a ton. The saving is not so much on operation of the boat but on the stevedore charges at each end of the trip, plus loss in weight from handling. Every means is used to save all grain bags in loading from the hold to the dock. Nevertheless the amount of several tons is lost on each trip in this crude way of handling.

Country elevator charges vary somewhat in different states and with different owners. One half cent to one cent a bushel is charged for weighing and storing thirty days and loading into cars. The price sometimes runs higher, but 50c a ton is a conservative price for a country elevator. If the grain is cleaned as usual in most country elevators, a charge of 40c a ton is added for the cleaning, and the screenings are returned to the farmer.

The charges at the terminal elevators in the East are from one half to one cent a bushel. According to the rates charged by the Public Terminal Grain Elevator of the Port of Seattle, the charges on the coast are 50c a ton for elevation from the cars, thirty days storage, outward wharfage and delivery in bulk into cars, or to vessels over grain conveying system.

Summing up, then, the cost of handling bulk grain after harvesting is:

Farm to country elevator, per ton	$1.50
Country elevator, per ton	.90
Terminal elevator, per ton	.50
Total cost, per ton	$2.90
Total cost, per 100 lbs.	.145
Cost of handling sacked grain after harvesting, per ton	$3.91½
Cost of handling bulk grain after harvesting, per ton	2.90
	$1.01½

According to the above figures, which must be regarded as only approximate, the after-harvesting saving in handling bulk grain is about one dollar per ton, in addition to which the farmer secures the screenings for use on the farm.

Decreased Amount of Grain Lost by Bulk Handling.

(1) *Losses from Handling Sacked Grain*

It is practically impossible to obtain any definite estimates of the losses in handling sacked grain. Most of these losses occur from leaky sewing and broken sacks. There is also a great loss from the floor of the "dog-house" and from the top of the sacks when sewing.

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Mr. Luke of Stockton says that the Sperry Flour Company lose, on the average, 14 tons or ½ of 1 per cent in shipping 2500 tons of sacked grain on barges from San Francisco to Stockton. He also says that from every 500-ton barge load received, there is a usual loss of from 2000 pounds to 4000 pounds, or 2 per cent to 4 per cent. This loss occurs from the trucking of leaky sacks.

Mr. Dozier and Mr. McCormick of Rio Vista are of the opinion that about 2 pounds of grain is lost for each sack that comes through the combined harvester before it reaches the warehouse. They attribute this loss to the shuffling of grain from the floor of the "dog-house" by the feet of the sewer and tender, failure to brush off the tops of sacks before dumping them, bursting of sacks in the field and on the wagon, and the cutting of the sacks by field mice in the field.

A prominent warehouseman of Sacramento has stated that the only profit that he made in the warehouse business came from the grain that he cleaned up from broken and cut grain bags.

Several grain warehousemen have stated that when grain is left in the warehouse for any great length of time as high as 40 per cent has to be resacked, due to the cutting of the mice and rats which are practically impossible to eradicate.

In the rulings of the Railroad Commission on the application of warehousemen for a raise in rates from 50c a ton to 75c a ton for unloading and storage for two months, the main reason given for the need of a 25c raise is the cost of resacking after storage.

(2) *Losses from Handling Bulk Grain*

There is no definite information available on the losses incurred from the handling of bulk grain. About the only loss on the farm would come from the leaky wagon beds. As this could be easily prevented there would be no reason for it but carelessness.

The loss in the country elevator is small. Around the elevators, even when they are running at full blast, there is practically no grain lying about on the floor. The opposite of this has always been seen in every warehouse. As all bins are made mouse- and rat-proof, there should be no loss from this source either on the farm or in the elevator, as is usually the case with grain in sacks.

Mr. Luke of the Sperry Flour Company of Stockton gives the loss in shipping and handling a 500-ton barge of bulk grain from San Francisco to Stockton as never over 300 pounds, which is an exceedingly small loss and is likely due to a great extent in the difference in two men weighing the same grain over different scales.

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Opinions of Farmers.

Through the county farm bureaus and their centers in various communities, the investigators consulted farmers in Solano, San Joaquin, Stanislaus, Madera and Kern counties. Some typical opinions expressed are as follows:

Mr. DOZIER: "The elevator is the best method of handling grain and it won't be long before we will have one in this town. It recently cost us $50 for labor and sacks to prepare 7000 sacks of grain for shipment, due to mice cutting the sacks."

Mr. MCCORMICK: "The elevator is the best method of handling grain and I think that it will come in time, but I don't believe that we are ready for it yet. I don't believe that it will work on the islands because of the weeds."

Mr. MCEADGEN, Dixon: "The bulk method of handling grain is undoubtedly the best method and we will have to come to it. I would like to have an experiment carried on here. The Farmers' Union has three warehouses and I think that they could be persuaded to change one of them over to the bulk system for handling grain."

Mr. KILKENNY, Dixon: "I think that the elevator will be a great saving to the farmer. He can cut his sack bill in two. At least I would like to try it, as I believe it will save money."

Mr. LAUGHLIN, Waterford: "I don't know much about the bulk-handling of grain, only that it is done. But when a man has to spend 10 per cent of his crop receipts for sacks to put his crop in, things ought to be changed. I don't know just how one would handle it off the harvester, but I don't see any reason why it couldn't be arranged by buying 500 or 1000 sacks and using them two or three times. If conditions can be fixed I am for it."

Mr. LOUIS BRIGETTO, Oakdale: "The bulk-handling of grain may be all right for the big grain sections, but it won't do with me, as I am too uncertain as to the amount of land that I farm and just where I farm it. This section is being cut up more every day and in a few years there won't be hardly any grain raised here, all the land will be fruit and alfalfa. There is always some waste from a harvester, but I don't know just how much."

SAMUEL HOWARD, Westley: "I think that the bulk-handling of grain is a good proposition and I am willing to try it if facilities are fixed for it. I spend around $1000 a year for sacks, which is a total loss to me. If I shipped in bulk, I would save it. Bulk-shipping ought to work fine here on the West Side, as it is a short haul to the track from either side."

RALPH ZACHARIAS, Patterson: "I spend about $2000 a year for sacks, which is practically a total loss to me. In our own warehouse here, where we keep about 3000 sacks, we lose from $300 to $500 a year from mice and rats. I would like to try the bulk-handling of my grain if arrangements can be made for it."

Mr. SCHMITZ, Madera: "The handling of grain in bulk would be a great saving to the grain farmers. I spend from $1500 to $2000 per year for sacks, which is a total waste. I had two men with ten mules and three wagons hauling 440 sacks a day. A sack buck picking up 700 sacks a day gets $3.50. Last year I stored 3600 sacks here on the ranch. When I hauled it to town in January I had to refill about 1000 sacks. If I had bins there would have been no need of this. I can install bins on my place very easily if facilities come so that it could be handled at Port Costa and the railroad centers. I would like to see a demonstration tried."

Mr. PANN, Chowchilla: "I cut eighty acres with a binder this year and it cost $1 an acre for cutting and $1 for twine. Thrashing costs 11c to 12c per 100 pounds. It cost a little more than a harvester but we more than twice paid for it in the savings of grain. Contract cutting by the harvester is done for from $1.75 to $2.25 per acre. We paid 9c for sacks. The losses from the harvester last year ran from 25 per cent to 50 per cent. There is one thing sure about the bulk-handling of grain, and that is we ought to handle our grain that way."

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Mr. VAN NOSTRUM, Tracy: "I think that it would be fine if we could handle our grain in bulk as they do in the East. It will be a great saving in sacks. We use the binder and believe that it is cheaper than the harvester because we do not lose so much grain in shattering. We lose some grain with the binder, due mostly to stacking bundles when the wind is blowing. The harvester can be made to get most of the grain when a man wants to make it in ideal cutting. It costs us 32c an acre for twine, about 50c to bind, and 10c or 11c a 100 lbs. to thrash. The stacking of the bundles is one of the biggest items. We get cleaner grain with the stationary thrasher than we do with the combined harvester."

Mr. D. W. JENNING, Manager Ramina Ranch, Tehachapi: "Please allow me to state that I made the change this last year and harvested 2500 acres and saved enough money by the change to pay for my complete installation of elevator and conveying system, together with bins and Invincible cleaning machine and smutter, making a total of close to $2000. I have outlined the practical cost for the change and based my figures on 1000 bushels per day. By this I mean that my harvester cut and threshed 1000 bushels and I hauled same to warehouse and by using elevator, put it into the bins in a ten-hour day.

"First: The cost of installing the necessary equipment on a combined harvester is very small and is done by simply building a small hopper, holding approximately fifty bushels, directly under the grain discharge. From this hopper I put in a spout of gravity flow to the wagon. These wagons were made grain-tight and were driven alongside the harvester, and as soon as full the hopper was shut off by a lever operated by the driver and the grain was then taken direct to the warehouse. From the time it is cut until it is in the bin, it is not touched by the hand of man. My dump is fixed by allowing the hind wheels of the wagon to drop into a small shoot and by opening the end gate the grain is allowed to run into the receiving pit of the elevator. The elevator consists simply of rubber belt with buckets for conveying the grain to upper conveyor and emptying direct into the bins. This installation can be made for about $25.00 if no conveyors are used, just simply dumping the grain into the bins, providing, of course, that you have power for running the elevators. If it is necessary to get power, a small 2½ to 5 h.p. engine will do the work in fine shape, making the total cost of perhaps $150. This is on a small scale and not equipped for general warehouse purposes.

"Second: Returning to the 1000 bushels per day. I used three four-horse teams, two of which operated between the machine and warehouse continuously, and the other four horses were used to load wagons from the harvester. These teams are figured at $6.50 per day, including driver. The only extra help I used was one man at the warehouse, and I allowed $5.00 per day for his wages and the fuel used to run the distillate engine, making a total cost of $24.50 per day to handle 1000 bushels of grain for harvester to the bins.

"Third: The old way of handling cost me last year, figuring on the same basis, using the three four-hourse teams, $71.80 and is itemized as follows:

Three teams at $6.50	$19.50
Sacks for 1000 bushels	36.80
One man on harvester as sack gig @ $2	2.00
One sack sewer	3.00
One man in warehouse to help pile	2.50
	$63.80

"On this same 1000 sacks I lost at least 10 per cent of the sacks that were destroyed by mice. etc., and had to replace them at a cost of $8.00, making a total cost of $71.80 as compared to $24.50 this year, a difference of $47.30 per day, on the basis of 1000 bushels threshed per day.

"Also I found in handling the grain in bulk this way there was no loss of grain from sacking, as everyone knows who has handled grain that there is more or less grain lost from the sacking stand on the separator and from the sacks being dumped on the ground, etc. Again I saved at least 10 per cent on my whole crop by being able to run the grain direct from the receiving pit into the cleaning and smutting machine and into the bin, all in one transaction. I am also able to convey my grain from the bins at any time to the cars by

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machinery. Another advantage to be gained by handling bulk grain is that in case of storm or bad weather the grain is all in the warehouse and not dumped upon the field.

"I am satisfied from my own experience that every farmer should equip himself to handle grain in bulk."

Opinions of Others Interested in Grain.

The opinion of buyers, shippers, warehousemen, milling companies, steamship companies, insurance underwriters, and manufacturing companies was asked on the practicability of bulk-handling of grain. Some of these follow:

AMERICAN-HAWAIIAN S. S. Co.: "It is not practicable to carry grain in bulk unless we receive large enough shipments to fill completely at least one lower hold of one of our steamers. Our ships carry a mixed general cargo and run on a schedule and it is not possible to carry bulk grain in them in parcel shipments. We have carried grain, but we carry it in sacks and do not bleed the sacks, and a requirement of ours is that the sacks shall be all new and free from sunburn. If the bulk system is gone over to and facilities are furnished for loading and a sufficient quantity can be had to fill one of the lower holds of our steamer, our New York people would probably take up the question of making arrangements for the carrying of bulk grain."

EAST ASIATIC S. S. Co.: "I have always held a view that it is indeed quite feasible for any ship to carry grain in bulk and, in certain instances, it would be a very great advantage because of the quicker handling. The difficulty to my mind does not appear to have ships, that is, steamers, carry grain in bulk but it is whether the outlook for grain export from California is great enough to involve erection of elevators."

Mr. GEORGE EGGERS, W. R. Grace & Co.: "A good deal of grain has been transported in bulk from Puget Sound and Columbia River to Sperry's Mill, South Vallejo. Vessels have to be equipped for the proper handling of this class of cargo, that is, shifting boards should be installed on the center line and holds properly lined so that grain will not become damaged by contact with ship's side and not get into bilges. Vessels get very good despatch, loading at the rate of about 200 tons per hour and discharging at the rate of about 150 tons per hour."

Mr. T. HENRY, ship broker: "Here on this coast we are fifty years behind time. All the grain on the Atlantic Coast is shipped in bulk. I don't see why we couldn't do the same here. Of course our ships are not all equipped for it now, but new types of boats are being built all of the time. I believe that the old sailing vessels and the steamers can be equipped rather cheaply to carry grain in bulk. The Panama Canal is going to greatly shorten the route so that it will become more advisable. I cannot give you any definite information, only that what I think. It will have to come up for trial."

Mr. A. F. PILLSBURY, surveyor of ships: "I think that shipment in bulk is the most economical way of transporting grain by sea as well as by land and river and bay transportation. In the East and on the Atlantic Coast most of the grain is handled in this way and I see no good reason why this practice should not be followed on the Pacific Coast, providing the Panama Canal be open, so that the ocean voyage will not be too long in transporting such cargoes from the Pacific Coast to the Atlantic Coast and Europe. There should be no trouble in transporting grain in bulk from the Pacific Coast to Japan and China. Many of the modern tramp steamers are constructed for the purpose of carrying grain in bulk."

Mr. T. CARY FRIEDLANDER, Secretary Grain and Trade Association, San Francisco: "The economic conditions in grain growing in California have been always much the same as they are today, save that shipping conditions are a little better, due to the more prevalent use of steamship and the opening of the Panama Canal. Economic conditions in the past have not brought it about,

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and I believe that if the bulk-handling of grain was that much better than the sacking of grain, conditions would have changed in the past.

"A change to the bulk-handling system from the present sack system will mean a complete change from the detailed equipment on the farm, the country warehouse, the rolling stock and crafts for transportation, and the terminal warehouses at tidewater. This change will require an enormous amount of capital. The only real saving will occur in the cost of handling, as the price of sacks will not be eliminated as deductions will be made for their cost in the purchasing price of bulk grain.

"There are places in this state where peculiar conditions exist which are adaptable to the bulk-handling of grain. Wherever these conditions exist the farmers will change over to the bulk system. The fact that a great percentage of our barley and wheat crop is sold for feed, and this feed is necessarily sold in sacks, and also since all the by-products of our mills are sold in sacks, goes to show that sacks are absolutely necessary to our conditions, and it doesn't make much difference whether the farmer or the grain buyer buys them."

Mr. HENRY C. BUNKER, Chief Grain Inspector, Chamber of Commerce, San Francisco: "I do not believe that to change over to the bulk system will be possible because of the cost of the change to the farmer, the warehousemen, the railroads, the distance which the farmer has to haul his grain and the customary use of sacks in the past."

Mr. VOLMER, Volmer & Perry, grain dealers: "The change may be possible, but it is not practical. Barley cut by a combined harvester produces a much better grade of brewing barley than that from the binder, being much brighter in color and more mellow."

G. W. MCNEAR, G. W. McNear & Co., Inc., San Francisco: "From an exporter's point of view it is entirely practicable to handle grain in bulk. In fact, it is preferable and more economical, but it would mean a complete rearrangement of our handling facilities from farm to tidewater; that is, interior elevators, different class of railroad cars, and suitable elevators at tidewater terminals.

"This would mean a considerable investment and it is a question whether the volume of business for export would justify it. The export of wheat from this state is insignificant, practically none today. We have and will continue to have for export several hundred thousand tons of barley. If in the future, the production of wheat and barley should increase and we should have for export the quantities that we had fifteen or twenty years ago, then it might be advisable to take up this question.

"Most of the local mills, both feed and flour, are equipped and could readily receive grain from the interior in bulk, and so far as the shipping interests at Port Costa are concerned, most of us are equipped to handle grain in bulk to a certain extent. While there are certain localities in the state where the interior interests migh be warranted in putting up small elevators, generally speaking, I don't think the matter under present conditions is of sufficient importance to go into the question in a large way of handling grain in bulk."

E. CLEMENS HORST CO.: "There is no doubt in our minds but that it will be only a short time until most of the California barley business will be done in bulk entirely. There will have to be some changes made in the methods of doing business, but the advantages of bulk-handling of grain are so great that there is no doubt but that the handling of the crop in sacks will eventually be discontinued."

Mr. E. H. SHIBLEY, Superintendent Port Costa Warehouse and Dock Co.: "Personally I would rather handle grain in bulk than in sacks, though the change necessary to be made in order to handle it in bulk would cost a great deal. Between June 1, 1913, and June 1, 1914, we handled almost 250,000 tons of grain through our warehouse, and the largest quantity we had stored at any one time was 58,000 tons. The number of men employed in receiving, cleaning, and shipping grain depends, of course, upon the quantity and quality of the grain handled. In July, 1914, our payroll showed 320 men, in August 286 men, in September 304 men, and in October 240 men. During the corresponding months of the year 1915 our payroll showed 136 men, 161 men, 129 men, and

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122 men, respectively. Warehousemen are paid 35c per hour for nine hours and they receive 52½c an hour for work after five o'clock, for night work, and for Sundays and holidays. Stevedores receive 55c per hour and are paid $1.00 per hour for night work and for work on Sundays and holidays. In one day of nine hours we loaded over 2500 tons of grain."

Mr. PERRY, Perry & Melone, Stockton, Cal.: "There is no doubt about the elevator system being the best and most economical system of handling grain, but the conditions under which grain is produced here in California almost prevents their establishment. The grain business is too unstable. We have large crops one year and small ones the next. The warehouse today is a loss and is maintained merely as a matter of convenience. We charge 2½c per hundred or 50c per ton for taking, weighing, storing one month and shipping grain. Twenty-five cents a month is charged for additional month's storage and $1.00 is charged for the entire season. Many warehouses are losing money. I wouldn't want to put up an elevator, depending on storage for income. It would be up to the farmer or some one else to build them."

Mr. STOWE, Farmers' Union and Milling Co., Stockton, Cal.: "The elevator system is the best system of handling grain because of economy in time and labor, but will take some time to bring about in California. I do not believe that the future of the grain business in San Joaquin County will warrant the building of elevators. Grain will be used in the future in a system of rotation only.

"The weeds in the island barley practically prevent it being put into an elevator until recleaned, which requires sacking first. If the sacks were left in the field two weeks and then cleaned, perhaps it could be elevated. It is a proposed radical change on account of the high cost of sacks this year, and just as soon as the cost of sacks drops to normal price the bulk-system agitation for handling our grain will be over.

"I believe that if any elevators are to be put up they will have to be put up by the farmers themselves, or by large organizations such as the Sperry Flour Co. and Globe Grain and Milling Co., who are in the milling business. It will be a long time before California adopts the elevator system. Why? Because it's a dying business—less acreage for grain every year, and who wants to put large amounts of money into strings of elevators?"

Mr. A. GRUNNEUR, Tracy: "If the farmers think it a good plan to change over to the bulk system and arrangements can be made for handling and shipping of bulk grain to and from Port Costa, I will be willing to make the change even if the cost is large. In keeping grain in the warehouse for six months we have to resack about 10 per cent of it.

"We have sold a great many binders during the past few years, but they have gone out west of here, where the wind is the heaviest and there is the greatest shattering. The farmers down below here laugh at you when you say anything about binders to them. I believe that the harvester is more wasteful than economical, in locations where the wind blows so strong as to shatter a lot of the standing grain before it is ready for the harvester."

Mr. TURNER, Grange Company, Modesto: "The bulk system of handling grain is probably the most economical for that portion of Stanislaus County where a good share of the crop is for shipment. You understand that certain portions of our grain-producing section serve our own local market, where it is more economically handled for delivery in sacks. Should terminal facilities for handling bulk grain be arranged for in California and the farmers in our section prefer that method of handling, we would be inclined to make arrangements to handle bulk grain in those sections of the country where we have warehouses, where there would be such a demand."

Mr. GEORGE STEWART, Grain Superintendent for Simon Newman Co., Newman: "The only thing that I see against the bulk handling of grain in this state is the change from the present system to the bulk system, which will do away with the warehouses."

Mr. SAUNDERS, Madera: "I have never thought much about the elevator system and have not seen an elevator in operation. There isn't any money in the warehouse business. It is all lost in excess labor, which can't be kept per-

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manently employed. If the elevator is much more of a saving I would be in favor of it, if it doesn't cost too much. I am in favor of all modern improvements that are a benefit to all concerned. The only money that I make is in my barley mill and the wholesale and retail business. It cost me about 50c a ton to put grain in the pile before I got my machine to pile with. Now it costs less. I have interviewed quite a number of people concerning the elevator system of handling grain. From what I have learned the same is not practicable at this time in this vicinity, for the following reasons:

"First. Grain land being subdivided.

"Second. Price of land being too high to raise grain.

"Third. Haul to Port Costa too short.

"Fourth. More diversified farming every year.

"Fifth. Land has been farmed for grain thirty years; does not pay any more.

"Sixth. It would take the railroad about eight years to equip for handling grain loose.

"Seventh. Our harvest is ninety days; too much money to install elevators for ninety days' work.

"Eighth. The farmers would receive less for their grain in bulk than in sacks, consequently would not save the price on sacks."

Mr. WOODS, Merced: "I don't believe that the present outlook of the future of California grain industry here on the east side would warrant the change. We have lost the use of two warehouses in the last few years due to irrigation and subdivision of the large grain ranches. Those warehouses which they are operating at present are about filled to their capacity in good seasons."

Mr. E. S. WAGENHEIM, Superintendent of S. Newman Co., Newman: "I have thought about the bulk-handling of grain a great deal the past two years, and believe that it is the only thing and that it will have to come about. Farmers have to pay altogether too much for sacks. I don't know what it costs to build elevators, but they will be built as soon as the railroads will furnish us shipping facilities. Also, elevators will have to be built at the terminals. In order to bring about the change you work on the railroad and terminal warehouse people for facilities, and the farmer and the shipper will soon fall in line."

Mr. NIEL NIELSON, Australian Commissioner at the P. P. I. E., made a report to the Government of New South Wales on the bulk-handling of grain. The Australian Government has laid plans to change over from the sack system to the bulk method of handling grain.

"A commission of engineers decided to make the change on my report and that of an American elevator builder who reported on the relative costs of their construction. The railroads, which are owned by the Government, are going to make the change, so the Government will indirectly stand the cost. Grain is now harvested in Australia with a harvester which has a 10-foot cut and is drawn by four horses. They cut about fifteen acres a day and are handled by one man. They are on the stripper plan. Grain is put in bags which weigh under 200 lbs. One stripper carries five sacks, which are set off the machine when full and sewn."

Mr. LUKE, Sperry Flour Company: "Our 1800 ton steel bins cost us, including foundations, $14,000. Our total expenditure was $25,000, but this included elevator on the wharf, carrier from wharf to bins and also reconstructing barge for bulk wheat. Our new wood bins, which hold a little over 3000 tons, cost us $21,000, but this included carriers from cars to bins and a long carrier belt from bins to mill. Our total cost for the bins and foundations above amounted to $17,000. We unload from the barge to the bins for 4c a ton. It used to cost us 10c a ton to place the sacked grain from the barge on the wharf, and 25c a ton to put it in the warehouse."

PHOENIX MILLING COMPANY, Sacramento: "Where great quantities of grain are handled, the bulk or elevator system is the best and cheapest. As the crop of wheat in California is growing smaller year by year it is doubtful whether it would pay to change over at this late day. A large portion of the California wheat crop goes out as poultry and stock food, and will have to be sacked anyway, and so it is with corn, oats, Egyptian corn, and other grain, which latter articles are not raised in sufficient quantities to justify building elevators for.

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"We have been asked by farmers whether they would get more for wheat in sacks than in bulk and our answer is that grain in sacks will certainly be paid for at a higher price and in the proportion to the cost of sacks and sacking.

"As far as we are, ourselves, concerned in this matter we have an eighty thousand bushel elevator in conjunction with our mill, and we prefer receiving grain in bulk instead of in sacks. This elevator is of reinforced concrete and cost us at the rate of $0.27 per bushel.

"The fact that the California farmer can leave his wheat in the field after sacking for three months or more after harvesting and before hauling to warehouse or selling, is quite a factor against handling the grain in bulk, in which latter case he would have to haul the grain to the elevator at once."

Mr. A. B. HASLACHER, Manager Oakdale Milling Co.: "The bulk system of handling grain works well in the East, where the binder and stationary thresher is used. In California, where the combined harvester is used, the grain is not cleaned so well and it is doubtful whether it would work so satisfactorily. Wheat which is well threshed might be handled in bulk, although the present tendency among millers is to keep each lot of California wheat separate, making the blend at the mill in accordance with the gluten test developed in each lot. Barley varies so greatly in cleanliness, that it would be difficult to bulk together several different lots for feed purposes, since farmers and buyers could not agree as to standards. Shipping or brewing barley would probably have to be kept separate in country elevators, the blending, if any, being done at terminal points. Shippers and maltsters like to do their own grading.

"Farmers in this vicinity have not stock enough to have their hauling keep pace with their threshing operations. It is customary in this vicinity to pile the sacked grain in the field, hauling later in the season when threshing is finished. Apparently, there is a certain convenience in this.

"The present agitation in favor of elevators is largely due to the abnormal price of jute grain bags, due to war conditions. The price of sacked grain will always be more than bulk grain. In buying Eastern wheat we pay 7½ cents more per cental for sacked grain than we do for bulk grain. In years previous to 1916, when the price of sacks was normal, this increase in price practically took care of the cost of sacks.

"There would have to be a change in railroad equipment as well as in terminal storage facilities to make possible handling of bulk grain. To make the change necessary at Port Costa alone, would involve the expenditure of hundreds of thousands of dollars, perhaps millions. There has been a certain unwillingness on the part of shippers and millers to expend a sum necessary to effect this change in a business which is waning as fast as grain raising in California. The warehousemen in the interiors, as a rule, would not be willing to make the change. Fifteen years ago our line comprised thirty warehouses well filled every year, most of the time unable to handle all the grain offering. At present we operate twenty warehouses and it is rare to find one more than indifferently filled. Every warehouseman will tell the same story. Owing to large areas going into other products, the amount of grain raised in California is constantly cut down.

"In conclusion, the present agitation is due primarily to the exorbitant price of sacks. When grain sacks emerge from the "War Baby" class, the storage of grain will proceed along the same old lines. There is a certain convenience of handling bulk, but there is also a certain convenience, as I have tried to point out, of handling in sacks. The immense cost of making the change would not be justified and will not be attempted in a general way."

Mr. W. E. SHEPHERD, Holt Mfg. Co.: "There is no question but that the farmers of California could save an immense amount of money if their grain could be handled in bulk, and I believe that in many parts of California it will be handled in bulk in the future. Of course in some sections of the country, where the raising of grain is being replaced by the raising of other products, an extensive elevator system would not be practical. But even in these sections, small elevators built by the farmers themselves will be used to a greater or less degree.

"As far as handling grain in bulk from combined harvester is concerned, the matter is very simple. All Holt harvesters can be equipped for handling

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bulk grain at a very small cost. In fact, harvesters that we have sent to Oklahoma and Kansas, where elevators are the rule, have all been equipped to handle grain in bulk. They have proved that the handling of bulk grain from combined harvesters is satisfactory. It has ceased to be an experiment with us."

Mr. J. W. DUVAL, Crop Technologist in charge Grain Standardization, Bureau of Plant Industry, U. S. Department of Agriculture: "I have to advise that there is no very definite information available as to the relative cost of these two methods, as so much depends on the volume of grain handled, management, and other factors. It goes without saying, however, that the cost of handling grain in sacks is very much greater than by handling in bulk. In our work we generally consider that the cost of bulk-handling is about one-fourth that of handling in bags, that is, for the handling alone. There is, of course, an additional cost to farmers in the expense of bags, which usually range from eight to ten cents or from four to five cents per bushel.

"In an article in the *Grain Dealers Journal*, Vol. 32, No. 8, issue of April 25, 1914, there is a brief summary of the report of the committee appointed to investigate the saving of handling grain by bulk on the Pacific Coast, which committee reported that in Oregon this would result in a saving of $660,000. In an article which appeared in the *Price Current-Grain Reporter*, Vol. 71, hl. 3, p. 19, issue of January 21, 1914, Mr. Louis Delivuk of Quincy, Wash., says that in 1910 the sack system reduced the net price received by farmers of Washington for their wheat by nineteen cents per bushel as compared with the average received by all farmers in the United States, and in 1911 the average was fifteen cents per bushel under the amount received by other farmers. In a short article in the *American Elevator and Grain Trade*, Vol. 32, No. 4, p. 182, issue of October, 1913, which article refers especially to the handling of grain on the Pacific Coast, it is estimated that the additional cost of handling in sacks for the Northwest is $2,000,000."

CONCLUSIONS

It is apparent that the bulk-handling of grain on California farms, either from the combined harvester or from the binder, is entirely practicable and would undoubtedly make for economy and for the betterment of the industry. It is also apparent that it is much more easily accomplished for wheat than for barley, due to the systems in vogue for grading the grains and to the fact that all California wheat is used in the state.

How much the actual saving would be for either cereal to the farmer is problematical, owing to the uncertainty of (1) the future comparative prices for sacked and bulk grain, (2) the varying distances grain must be hauled from the farm, and (3) the future price of sacks.

The greatest saving by handling grain in bulk is after the grain leaves the farm. The contention that the old sacked system of handling grain is necessarily inherent to California is amply disproved by the experience of other grain-producing countries which, prompted by governmental investigation, have changed from the sacked to the bulk system with the advent of the grain-carrying steamship.

In the last twenty years, California has changed from a wheat exporting to a wheat importing state. Meanwhile the production of

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barley has so greatly increased that the export problem of grain-handling is largely confined to barley. Since wheat in California is largely consumed inside the state, it is much more readily possible to handle that grain by bulk since no export problems are thereby encountered.

The bulk-handling of barley is attended with greater difficulty than that of wheat, due to the fact that barley is purchased more upon its physical appearance than upon its chemical quality. Brewers have been in the habit of purchasing barley in individual lots on the theory that the germination of these lots would be uniform and therefore the brewing quality of the product would be of higher grade than otherwise. Because the change from the sacked to the bulk-handling of barley necessitates the mixing of various lots, the difficulties are greatly increased.

Of the six changes which the shift from the sacked to the bulk method would make necessary for export grain, three lie beyond the farm and rural community. It is easy to conceive that farmers may (1) equip harvesting machinery to handle bulk grain, and (2) build grain bins or portable elevators on the farm, and that (3) elevators may be built by co-operative effort at local shipping points. It is not so easy, however, to predict that the other necessary changes can be accomplished merely by the agitation of farming communities. These are (4) the erection of a great terminal elevator, (5) equipment of rolling stock, boats and ships to carry bulk grain, and (6) the permanent opening of the Panama Canal. Of these the most important, and for the present the most uncertain, is the erection of a terminal elevator to accommodate the export grain.

Until some plan is under way for a terminal elevator and until grain ships are equipped to carry bulk grain through the Canal, it is evidently undesirable for the barley ranchers to make any large expenditure for building local elevators, farm grain bins or bulk grain harvester attachments.

If the time comes to erect local elevators at shipping points it may be well for the farmers of California to profit by the experience of middle western states. It was there learned by bitter experience that unless there were more than one local elevator to which farmers could ship, or unless the local elevator were maintained by some co-operative enterprise for the common benefit, the likelihood of monopolistic control and of consequent dissatisfaction was greatly increased. If it is desirable to ship in bulk it thereby becomes desirable to build upon the co-operative plan such local elevators as may be necessary.

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UNIVERSITY FARM SCHOOL

CIRCULAR No. 153
JULY, 1916

ANNOUNCEMENT OF THE CALIFORNIA STATE DAIRY COW COMPETITION, 1916-18

BY F. W. WOLL

The College of Agriculture of the University of California will conduct a competition for dairy herds during the coming year, in connection with the official testing of dairy cows for production of butter-fat in which work the college has been engaged for a number of years past. The competition has been rendered possible through the hearty co-operation of breeders of pure-bred dairy cattle, feed dealers, creamery companies, and other parties interested in the advancement of our dairy industry, who have subscribed a fund of over $4700 for the award of prizes for records of production made by cows in the competition. A number of special prizes of pure-bred bull calves, dairy apparatus, and feeds have likewise been donated in order to make the competition of general interest to dairy farmers and to insure a large participation in it.

CONTRIBUTORS TO PRIZES IN THE COMPETITION

Contributions to the cash prize fund and of special prizes have been received from the following parties:

A. *Cash Prize Fund.*—Alexander and Kellogg, Suisun; Mrs. Anita M. Baldwin, Santa Anita; Balfour, Guthrie & Co., San Francisco; "Calf-Way" Milker Co., San Francisco; California Central Creameries, San Francisco; De Laval Separator Co., New York City, New York; W. H. Dupee, Santee; J. S. Gibson Co., Williams; F. M. Helm, Fresno; Miss M. M. Holdridge, Modesto; Larrowe Milling Co., Los Angeles; Millbrae Dairy, Millbrae; A. W. Morris & Sons Corp., Woodland; B. E. Nixon, Yountville; Pacific Dairy Review, San Francisco; Palo Alto Stock Farm, Palo Alto; Sacramento Clearing House, Sacramento; Somers & Co., San Francisco; Sperry Flour Mills, Stockton; State Holstein Breeders' Association, Chino; State Jersey Breeders' Association, Stockton; F. Stenzel, San Lorenzo; Western Creameries Co., San Francisco; G. W. Wilder, Redlands.

B. *Special Prizes.—Pure-bred bull calves.*—K. W. Abbott, Milpitas; J. W. Clise, Seattle, Washington; Dr. J. W. Henderson, Berkeley; A. B. Humphrey, Mayhews; N. B. Locke Co., Lockeford; C. G. McFarland, San Francisco; W. H. Saylor, San Francisco.

Feed.—Larrowe Milling Co., Los Angeles.

Cream separators.—Associated Mfrs. Co., Waterloo, Iowa; Baker & Hamilton, San Francisco; Beck Hardware Co., San Francisco; De Laval Dairy Supply Co., San Francisco; Empire Cream Separator Co., Bloomfield, New Jersey; International Harvester Co., San Francisco.

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Milking machines.—"Calf-Way" Milker Co., San Francisco; Sharples Separator Co., San Francisco.

Trophies and medals.—American Guernsey Cattle Club, Peterboro, New Hampshire; American Jersey Cattle Club, New York City, New York; Holstein-Friesian Association of America, Brattleboro, Vermont; Scott, Magner & Miller, San Francisco.

Special cash prizes.—California Cultivator, Los Angeles; McAlister & Sons, Chino; Livestock and Dairy Journal, Sacramento; Pacific Rural Press, San Francisco; the Country Life Department of the Sacramento Bee, Sacramento; Barber & Thomson Co., Los Angeles.

The distribution of the prize fund for cash prizes, and the special prizes offered in the competition will be seen on page 3 of this circular.

CONDUCT OF THE COMPETITION

The production by the cows entered in the competition will be determined by the method adopted in the semi-official testing of dairy cows for yearly records of production. About twenty young men, especially interested and trained in dairying, most of them graduates of the College, or of the short courses offered by the University of California, are at the present time employed in this work. They visit the various ranches for two days every month, during which period they are present at every milking of the cows, carefully weigh and make fat determinations in the milk, and make out reports on the production of milk and butter-fat for the two-day periods. The average per cent of fat in the milk for the two days is taken to represent the average quality of the milk during the month, and the milk yield reported by the owner and verified by the College or the respective breed associations, multiplied by this percentage, gives the production of butter-fat for the month. Such production for twelve consecutive months will give very closely the actual production for the year, and cows are admitted to the advanced registers of the various breed associations when these figures exceed the minimum requirements for cows of different ages that have been adopted by the respective associations.

The method of conducting the official tests and details concerning the system of testing dairy cows for production are explained in Circular 135 of the California Agricultural Experiment Station,[1] a copy of which will be sent to residents of the state upon request. Address, Director Agricultural Experiment Station, Berkeley, Calif.

In the competition to be conducted as above explained, the production by cows during the period of ten months will form the basis of awarding the prizes offered, instead of that for a period of one year.

[1] Official tests of dairy cows, by F. W. Woll and Cora J. Hill. Circ. No. 135, Calif. Agr. Exp. Station, August, 1915.

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for the reason that in ordinary dairy practice cows drop a calf once every twelve months and are dry for from four to six weeks every year. When cows are tested for yearly records, many breeders are tempted to delay breeding their cows until late in the lactation period and to feed very heavily so that the cows will give milk for the entire 365 days, with the result that the breeding operations are seriously interfered with and the production by the cows during the following year is greatly decreased. By limiting the record period to ten months, cows may be regularly bred so as to drop a calf at intervals of about twelve months, may go dry for at least a month, and the future usefulness of the cows in the herd will not be jeopardized. Breeders who are anxious to obtain good results from their cows beyond the special period while they are placed on tests may, therefore, enter their cows in the competition without danger of interfering with the general system of herd management adopted.

COMPETITION OPEN TO ALL KINDS OF COWS

The competition is not restricted to pure-breds, but is open to all kinds of cows, including grades, and cows of mixed breeding. Cows of the latter classes do not come into competition with pure-breds in the awards of most prizes, since a considerable number of the prizes are awarded for records made by such cows only. The value of the cash prizes to be competed for by grades alone amounts to over $1000, and a large number of special prizes will be awarded for records made by grade or common cows, or by cows irrespective of their breeding. It is hoped that the provision made for liberal prizes for this class of cows will appeal to many farmers owning common dairy herds and that they will enter cows in the competition in large numbers.

PRIZES OFFERED IN THE COMPETITION

The following prizes will be awarded for records made in the competition:

I. *Herd Prizes*: For the highest production of butter-fat by ten cows in a herd during ten consecutive months:

	1st Prize	2nd Prize	3rd Prize	4th Prize	
(*a*) Jerseys or Guernseys	$300.00	$200.00	$100.00	$50.00	
(*b*) Holsteins	300.00	200.00	100.00	50.00	
(*c*) Grades and other cows not included in groups (*a*) or (*b*)	300.00	200.00	100.00	50.00	
Total (12 prizes)					$1950.00

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II. *Individual Prizes*: For the highest production of butter-fat by a cow during ten consecutive months:

(*a*) Jerseys or Guernseys	$200.00	$100.00	$50.00	$25.00	
(*b*) Holsteins	200.00	100.00	50.00	25.00	
(*c*) Grades and other cows not included in groups (*a*) or (*b*)	200.00	100.00	50.00	25.00	
Total (12 prizes)					$1125.00

Special Prizes.—In dairy bull calves, dairy apparatus, feed, cash, trophies, etc.

A. *Pure-bred Bull Calves.*—

1. *For the highest average production of butter fat during 10 consecutive months, by a grade herd of 10 to 25 cows headed by a pure-bred sire,* four prizes, choice of:

An Ayrshire, Guernsey, Holstein, or Jersey bull calf—donated, respectively, by J. W. Clise, Seattle, Washington; A. B. Humphrey, Mayhews, California; K. W. Abbott, Milpitas, California; and N. B. Locke Co., Lockeford, California.

2. *For the highest average production of butter fat during 10 consecutive months, by a grade herd of more than 25 cows, headed by a pure-bred sire,* four prizes, choice of:

An Ayrshire, Guernsey, or Jersey bull calf, donated, respectively, by E. B. McFarland, San Francisco, California; W. A. Saylor, San Francisco, California; C. G. McFarland, Tulare, California; and of $100 worth in pure-bred Guernsey or Hampshire males, donated by Dr. J. W. Henderson, Berkeley, California.

B. *Milking Machines, Cream Separators, Feeds.*—

3. *For the two herds having the largest and next to the largest number of cows producing over 300 pounds of butter fat in 10 consecutive months,* two prizes, choice of:

A 2-unit outfit of the "Calf-Way" Milker, donated by the "Calf-Way" Milker Company, Chicago, Illinois, and a 2-unit Sharples Mechanical Milker, donated by the Sharples Separator Company, West Chester, Pennsylvania.

Milking machines are awarded for use in winner's herd only.

4. *For the highest average of butter fat by 10 cows in a grade herd,* five prizes (winner of first three cash prizes barred), choice of:

A No. 35 Iowa Cream Separator, capacity 850 pounds per hour, donated by the Associated Manufacturers Company, Waterloo, Iowa.

A No. 5 Simplex Cream Separator, capacity 500 pounds per hour, donated by Baker & Hamilton, San Francisco, California.

A No. 6 Anker-Holth Cream Separator, capacity 600 pounds, donated by Beck Hardware Company, San Francisco.

An M-2 Baltic Cream Separator, capacity 300 pounds per hour, donated by the Empire Cream Separator Company, Bloomfield, New Jersey.

A No. 2 Primrose Cream Separator, donated by the International Harvester Company of America, San Francisco.

5. *For the highest average production of three cows in the same herd, 2½ years to 3½ years old at the beginning of the Competition,*

A No. 15 De Laval Cream Separator, capacity 675 pounds, donated by the De Laval Dairy Supply Company, San Francisco, California.

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6. *For the highest production of butter fat during 10 consecutive months by a cow entered in the Competition,*

5 tons of Larrowe's Dried Beet Pulp, offered by the Larrowe Milling Company, Los Angeles, California, *provided,* that if the winner of this prize consumed not less than one half-ton of Larrowe's Dried Beet Pulp in her ration during the record period, the quantity to be awarded shall be increased to 15 tons.

C. *Cash Prizes.—*

7. *For the highest production of butter fat during 10 consecutive months by five cows in a herd, bred by the owner,* three prizes:

$150 each for (*a*) pure-bred cows, (*b*) grade cows, (*c*) cows irrespective of their breeding—offered by the Country Life Department of The Sacramento Bee, Sacramento, California. No cow shall compete in more than one of these groups.

8. *For the highest and next to the highest production of butter fat during 10 consecutive months by a cow in the Imperial Valley,* two prizes, respectively:

$25 and $15, offered by Barber & Thomson Company, Los Angeles, California.

9. *For the highest average production of butter fat by 5 cows in a grade herd, headed by a pure-bred sire, during each calendar month, November, 1916, to February, 1918, inclusive:*

A cash prize of $25 per month, donated by the Pacific Rural Press, San Francisco, California—The same individual cows shall compete only once for this prize.

10. *For the highest production of butter fat for one year by herds belonging to a cow-testing association,* three prizes:

One hundred dollars each for herds of (*a*) 10 to 25 cows, (*b*) 26 to 50 cows, (*c*) over 50 cows; offered by the California Cultivator, Los Angeles, California.

Association records for twelve consecutive months during the period of November, 1916, to February, 1918, will be considered in the award of these prizes; entries to close February 28, 1917. All heifers and cows in milk during six months or more must be included in the average for the herd.

11. *For the highest production of butter fat by a grade cow for each month during the year 1917:*

A cash prize of $10 a month, offered by McAlister & Sons, Chino, California Records made by the same cows shall only be considered once in the award of this prize.

12. (*a*) *For the highest average production of butter fat by ten cows in a grade herd, headed by a pure-bred bull out of a dam with a semi-official yearly record at least 10 per cent in excess of the average butter fat production of the herd, and*

(*b*) *For the highest average production of butter fat by ten cows in a registered pure-bred herd, covering a period of ten months.*

Two prizes of $150 and $100, respectively, offered by the Livestock and Dairy Journal, Sacramento, California.

D. *Trophies and Medals.—*

13. *For the highest production of milk during 10 consecutive months by a cow irrespective of her breeding:*

A silver trophy, donated by Scott, Magner & Miller, San Francisco, California.

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14. *For the highest records of a registered Jersey cow and by 10 cows in a grade herd, sired by a registered Jersey bull:*

Two cups, offered by the American Jersey Cattle Club, New York City, New York.

15. *For the highest records by a registered Guernsey cow and by 10 cows in a grade herd, sired by a registered Guernsey bull:*

Two trophies, offered by the American Guernsey Cattle Club, Peterboro, New Hampshire.

16. *For the highest records by a registered Holstein cow and by 10 cows in a grade herd, sired by a registered Holstein bull:*

Two silver cups, offered by the Holstein-Friesian Association of America, Brattleboro, Vermont.

17. *For the largest production of butter fat during 10 consecutive months by a cow bred by the owner:*

One gold medal.[2]

18. *For the largest production of butter fat during 10 consecutive months by 5 cows in a herd, bred by the owner:*

One gold medal.[2]

SUMMARY OF PRIZES OFFERED

	Number	Approximate Value
Cash prizes for 10 months' records (prize fund)	24	$3175
Cash prizes for 10 months' records (special prizes)	10	1040
Cash prizes for monthly records	28	520
Special prizes in dairy apparatus, etc.	26	2670
	88	$7405

In addition to the preceding prizes, at least one of the creamery companies of the state will pay one-half of the expense incident to the testing of herds owned by their patrons.

The rules governing the conduct of official tests, and details relating to their conduct, will be found in Circular 135, above referred to, and will not be repeated here. The following special rules will govern the conduct of the competition.

RULES GOVERNING THE COMPETITION

1. Any cow owned by a resident of the State of California may be entered in the competition.

2. The awards of prizes offered in the competition, except as otherwise given, shall be made on the basis of the production of butter-fat during a period of ten consecutive months, as determined by the system of semi-official testing of dairy cows.

3. Cows entered in the competition shall be tested for two days of every month, as arranged for by the rules governing semi-official

[2] Cost defrayed from donations to prize fund received in excess of cash prizes offered in the competition.

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yearly tests in this State. Grade cows may, however, be tested for only one day each month, if desired.

4. In order not to place young animals at a handicap in the award of prizes, the records for production actually made by cows under five years of age shall be increased in accordance with the average results obtained in authenticated yearly tests of cows of different ages, as follows: Records made by cows under 2½ years at the beginning of the test shall be increased by 30 per cent, and those made by older heifers and cows shall be increased as follows: for heifers 2½ to 3 years old, by 24 per cent; for cows 3 to 3½ years, by 18 per cent; 3½ to 4 years, by 15 per cent; 4 to 4½ years, by 8 per cent, and 4½ to 5 years, by 5 per cent.

5. The owner shall furnish a correct monthly statement of the amount of milk produced by the cows entered in the competition and of the kinds and amounts of the different feeds eaten by them. Blanks for reporting milk yields and the feed eaten will be furnished free of charge for this purpose. Milk records calculated from the data obtained in the monthly tests may be used, at the option of the Experiment Station authorities, for arriving at the production of the cows, in the place of those reported by the owners or where regular milk records are not kept by the owner.

6. Records of production for the competition may begin on the fifth day after calving and shall close ten months from the date of the beginning of the test. A cow will not, as a rule, be tested prior to the fourteenth day from freshening. When an official test of a cow in the competition, of seven days' duration or longer is conducted during a month, the average fat content for this period shall be used for the calculation of the production of butter-fat by the cow during that month.

7. Failure to get a cow in calf before the end of the fifth month after calving shall bar her from competing for any but the monthly prizes and the trophies offered by the various breed associations.

8. The cost of the monthly two-day tests conducted in connection with the competition shall be $7.50 for each farmer, and that of one-day tests of grade cows, $5. This cost includes all direct expenses of the tests to farmers, except room and board of the supervisors while on duty, and transportation to and from the nearest railway station or ranch where tests are conducted.

9. The maximum number of cows in a herd that may be tested at one time shall be fifteen if the cows are milked twice a day; ten if any are milked three times a day; and eight if any are milked four times

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a day. No cow entered in the competition shall be milked more than four times a day, and this number of times only when yielding over 60 pounds of milk per day.

10. The maximum amount of prize money paid to any one breeder (exclusive of monthly and special prizes) shall be $500. Prizes shall only be awarded to the bona fide owner of a cow at the time her record is completed. Only records of production of 365 pounds of butter-fat or more by pure-bred cows for ten months shall be considered in the award of cash prizes.

11. Where a choice of two or more prizes is offered, the highest production shall entitle the owner to first choice, the next highest to second choice, etc., in the order of decreasing production.

In the award of prizes to be made in the Competition, it shall be considered that a grade cow is the progeny of a pure-bred bull and a grade or common cow, and that a common or "scrub" cow is the progeny of a "scrub" or a grade bull.

12. All questions not covered by the preceding rules or by the rules governing the semi-official tests in this state, shall be decided by the Chief of the Division of Animal Husbandry in the College of Agriculture of the University of California, whose decision shall be final.

Applications for entry in the competition may be made any time prior to May 1, 1917, when the entries will close. Records of production may commence on November 1, 1916 and prizes will be awarded for records for ten consecutive months made prior to March 1, 1918. Entry blanks and further information concerning the competition will be furnished upon request. Address, *Professor F. W. Woll,* in charge of dairy tests, University Farm, *Davis, California.*

The California State Dairy Cow Competition offers a rare opportunity for breeders and dairy farmers to have records of production by their cows considered in the award of the many and substantial prizes offered in the competition and at the same time to get their pure-bred cows into the Advanced Registers of the various breed associations. For this reason, and on account of the general advancement of the dairying industry of the state, which will result from a large participation in the competition, it is hoped that all breeders of dairy cattle so situated that they can enter cows in the competition, and farmers who own cows of exceptional productive capacity, whether pure-breds, grades, or of mixed breeding, will avail themselves of the opportunity offered by this competition to establish the value of their cows for dairy production.

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IRRIGATION PRACTICE IN GROWING SMALL FRUITS IN CALIFORNIA*

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The census returns show that in the period between 1899 and 1909 the acreage in small fruits in California was increased more than fifty per cent, and that the production and value of the fruits were nearly doubled. In 1909, strawberries led with 4,585 acres, or nearly one-half

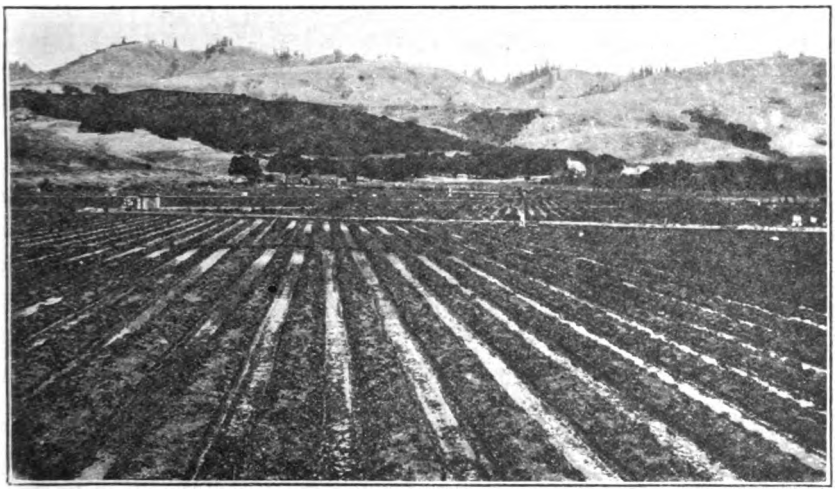

Fig. 1.—Strawberry field in Pajaro Valley. This shows the location of plant beds, irrigation furrows, and distributing flumes.

of the whole area devoted to small fruits, followed by blackberries and dewberries with 2,576 acres, raspberries and loganberries with 1,992 acres, currants with 407, gooseberries with 74, and cranberries with 53 acres. The irrigation of these small fruits is a very important factor

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in their production, and the present circular has been prepared for the purpose of describing and analyzing the irrigation practices in the important berry centers of the state.

PREPARATION OF LAND FOR IRRIGATION

In most sections of California small fruits are grown under irrigation, so that it is necessary to take into account careful preparation of the land before planting. It is especially essential that strawberry fields be well graded, because the streams of water used are quite small, and because, unless the land has an even slope, the application of water will not be uniform, but water will collect in depressions and flood over the berry vines, sometimes killing them if continued for any length of time. Less care is usually employed in preparing land for bush berries, however, and the "finishing" process referred to below is often omitted. When a strawberry field is laid out according to one of the most widely-used furrow systems, described later, the ridges and irrigation furrows are made to be permanent during the life of the planting, but the furrows in a blackberry or raspberry field are usually plowed up and renewed every year, with the result that less care is taken in making them. Furthermore, there is less danger to the plants from minor irregularities in the irrigation of bush fruits, as these are set quite far apart and are deeper-rooted, making unnecessary a close approach of the water to the plants. With the shallower-rooted strawberries, on the other hand, it is desirable to carry the water as close to the tops of the ridges as possible without actually flowing over them. Nevertheless, a carefully established grade is highly desirable in bush-berry fields as well as for strawberries, for where the handling of water is once made easy, the saving in labor and cost of water may in some years represent the difference between profit and loss.

SURVEYING

A survey of the field is the first step in its preparation for irrigation, and a contour map is of much assistance. The following method of laying out strawberry fields is used satisfactorily in parts of Pajaro Valley on gently rolling land: The high edge of the field is first chosen for the location of the main irrigation flume. Then after determining from the contour map the various positions of furrows and lateral flumes, which are such as to require the least grading, each lateral flume line is marked out on the ground and stakes are driven every 30 or 40

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feet along such line. Through the first stake a line of levels is run in the direction the furrows are to take, which is not necessarily at right angles to the lateral flume, and grade stakes are set every 30 feet, balancing the cuts and fills. This grade is usually 1 to 2 inches per 100 feet, or else the furrows are made level from end to end. Then an average line is run through the next stake parallel to the first line and grade stakes are set similarly, and the operation is repeated through each stake along each of the lateral flumes. Some growers set stakes every 50 feet apart, but this of course depends upon the character of the ground, more stakes being required when the surface is rough than when it is fairly level. The cost of surveying is from $2.00 to $2.50 per acre.

PLOWING AND CULTIVATING BEFORE PLANTING

Plowing and harrowing are not only indispensable in securing a good bed for planting, but are necessary in many cases to loosen the soil so that it may be easily moved by the leveling implements. The practice in some sections is to plow twice before grading, the first time to a depth of 8 to 12 inches and the next time shallower, and to harrow after each plowing, continuing the harrowing as occasion may require until grading has been completed. Other growers plow before and after leveling, and still others only afterwards, cultivating the ground several times thereafter. To avoid a dead furrow in the center of a small tract the practice sometimes is to run the plow once up and down the center line of the field, throwing the soil outwards, and then to reverse the plow and go up and down the furrow, throwing the soil into it, and so on around the field, the last work being done along the borders. Although this leaves a low area around the edges of the tract, it is less objectionable than a trench through the center. The total cost of the several plowings and cultivatings varies from $5 to $10 or more per acre, depending upon the number of operations.

GRADING

Methods of leveling land for small fruits and implements used are found to vary somewhat in different sections. The Parajo Valley method used in conjunction with the surveying practice described above is as follows: If the cuts and fills are very great a Fresno scraper is used first and the finishing is done with a "berry leveler," (fig. 2), and if not great the leveler is used alone. This implement has two wheels on an axle 7 feet or more long, to which is attached an adjust-

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able wooden drag, shod with iron, and having aprons on the side. It is drawn by one or two horses, depending upon the size. Very close work can be done by the driver standing on the machine and operating the adjusting lever. With this leveler the ground is worked back and forth along the line of the grade stakes for 15 feet on each side, or half the distance to the next row of stakes; then it is taken to the next line and the ground on each side of that leveled independently of that on each side of the first line; and so on down. This method is followed because it is more essential that each furrow shall have its proper grade than that any set of furrows shall bear a particular relation to an adjoining set. However, in case of a deep swale the line of the

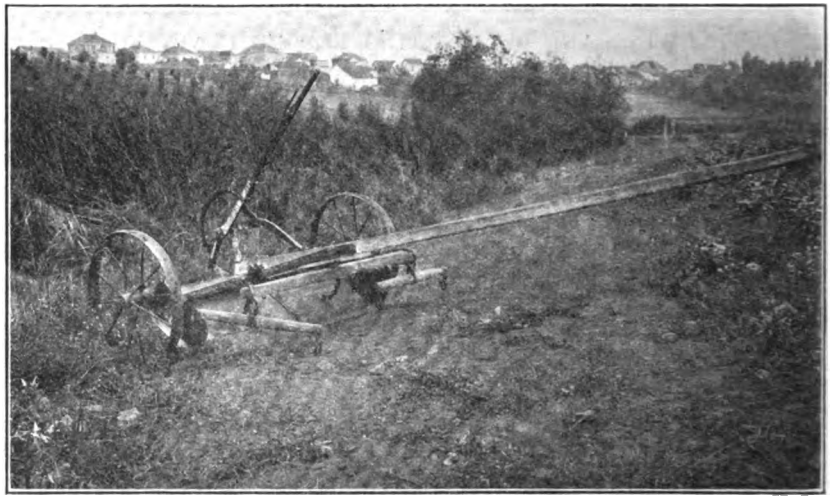

Fig. 2.—Leveler used in Pajaro Valley berry district. This is used for the final grading after the field has been leveled approximately with Fresno scrapers.

ditches may be changed to fit it. This method is peculiarly adapted to fairly rolling land where it is not desired to make long hauls with the scraper.

On the level valley floor lands of the state the usual practice is to level each small field as a whole and to run all furrows in the same direction.

In some sections, after leveling the field approximately to the grade stakes, the "finishing" is done with a drag or float. This consists of two 2-inch by 12-inch planks 12 to 16 feet long set parallel on edge and connected by three 2-inch by 12-inch cross-pieces 5 to 8 feet

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long, one at each end of the structure thus formed, and the third in the center. Diagonal strips of wood are used as braces. The central cross-plank is set on edge and vertical, but the two outer pieces slant backwards from top to bottom. This implement is drawn by two or more horses.

A satisfactory and inexpensive home-made leveler for berry fields in use in the Gardena-Moneta section of Los Angeles County is shown in figure 3. The rear wheels are mower-wheels, set on an axle 5 to 6 feet long, and the single front wheel is of any convenient material and size. The side boards are 2-inch by 12-inch planks 8 to 11 feet or more in length. The scraping device, which is controlled by a lever, is 4 to

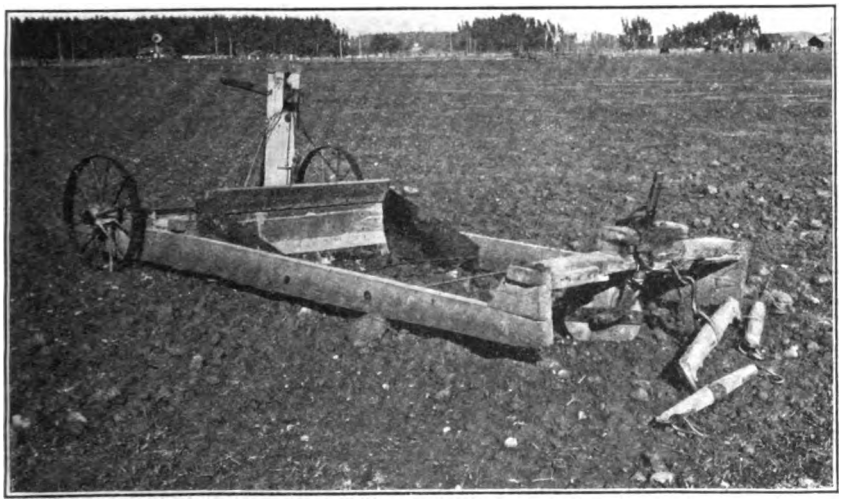

Fig. 3.—Leveler used in Gardena-Moneta berry district. A simple and cheaply made implement, used for final grading.

5 feet in width, made of 2-inch by 6-inch pine fitted over curved cleats and shod with iron on the bottom edge. The side shields or aprons are of galvanized iron. The smaller implement is drawn by two horses and the larger by four, the driver standing on the floor back of the adjusting lever.

Where large heads of water are available the precaution is sometimes taken to flood the field after leveling and then to fill the settled spots.

If the berry field is to be laid out on a steep hillside, which is often done in Pajaro Valley and elsewhere, no grading is done, but the irrigation furrows are made to follow the contours of the hill (fig. 4). The practice in the Sierra Nevada foothills of Placer County is to run

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the furrows directly down the slope instead of along the contours, thus following the system used extensively there in orchards. This is feasible where very small streams of water are run for long periods of time. With such irrigation practice, no preparation of the land is attempted other than to provide a proper bed for planting and to make the small furrows.

No figures can be given on the cost of leveling land that will apply to all conditions, because the cost depends entirely upon the character of land to be graded. Such cost may range from $3 to $4 up to $40 or more per acre, but the maximum is seldom expended in the case of small fruits unless the land is to be kept permanently in some irrigated crop.

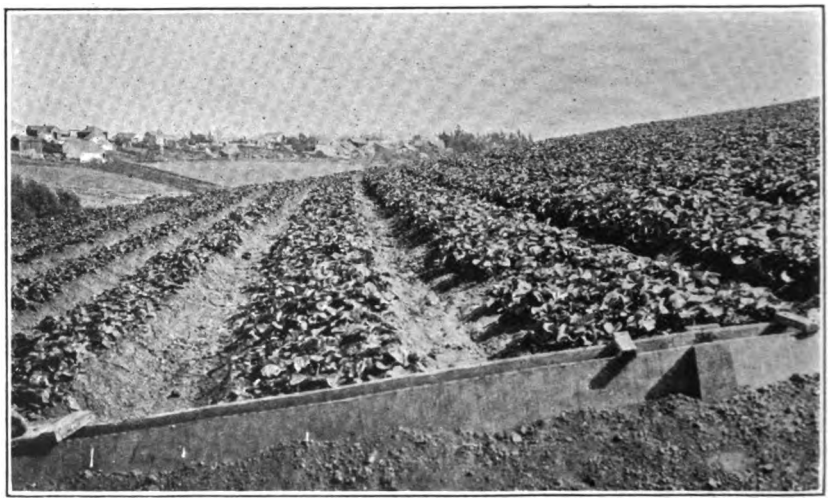

Fig. 4.—Sidehill planting, Pajaro Valley. Where strawberry fields are laid out on hillsides in this section, the irrigation furrows are made to follow the contours of the land. In Placer County the furrows are smaller and run directly down the slope.

HEAD DITCHES AND FLUMES

After grading, the tract is ready for the installation of ditches and furrows. The main conduit and supply laterals may be earthen ditches, open flumes, or pipes, the most widely used being small wooden flumes. Earth ditches may be made at a small initial cost, $2 or $3 per acre, but the labor and consequent cost of applying water will be increased because of the operation of opening and damming up furrows at each irrigation. Another disadvantage lies in seepage losses. Wooden

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flumes, on the contrary, require only a small amount of attendance, and leakage may be kept at a minimum. Concrete flumes or underground concrete pipe would be more satisfactory in all respects than either and have longer life than wood structures, but their high first cost, amounting to about double that of wood, has been sufficient to deter berry growers from installing them for the comparatively short time land is usually kept in irrigated small fruits, and they are seldom found in practice. The use of iron surface pipe is not extensive in the irrigation of small fruits.

Small earth ditches are used extensively in berry irrigation in lower San Joaquin Valley. They are also found in Placer County and in a few sections of southern California. Conditions encouraging their use are the low first cost and an ample water supply.

Wooden flumes are very commonly found in Pajaro Valley, Santa Clara Valley, and the southern California berry centers. In Pajaro Valley rectangular boxes are used, the main flumes being 12 by 14 inches and the laterals 8 by 10 inches, outside measurement; i.e., the box is constructed of three pieces of 1-inch by 12-inch or 1-inch by 8-inch lumber, as the case may be, the sides being nailed outside the floor and making the inside measurement 11 by 12 and 7 by 8 inches, respectively. Small cleats are nailed across the top at intervals of 2 to 8 or 10 feet to brace the sides, and occasionally these braces extend completely around the flume. The inside of the flume is partially or wholly painted with tar or the joints are covered with tarred paper to insure water-tightness. Sometimes pieces of lath are nailed outside over the vertical joints. Wherever possible the flume box is laid on the ground, but when crossing a swale simple wooden supports are used (fig. 5). The main flume between the berry field and pumping plant, where it must be raised in order to provide sufficient grade, rests upon a more elaborate trestle (fig. 6), consisting of 2-inch by 4-inch bents and caps, braced with 2-inch by 4-inch cross-pieces, set about 8 feet apart. Diagonal braces are provided where necessary to give additional strength or to supplant the horizontal braces. For crossing deep, narrow gullies, suspension bridges with triangular trusses are in use. Inverted siphons are frequently placed at road crossings. The grade of the main flume is usually about 3.5 inches in 100 feet, and of the laterals 1 to 2.5 inches in 100 feet.

In some parts of Santa Clara, San Fernando, and San Gabriel valleys and elsewhere a V-shaped flume is more common than the rectangular flume. This is made of two 1-inch by 12-inch or 1-inch by 8-inch timbers joined at right angles and braced at the top or com-

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pletely around by cleats nailed at intervals of a few feet. The construction of this type is somewhat simpler and the liability to leakage less than in case of the rectangular form, but some side support must be given the V-flume even when it is laid flush with the ground. With very small heads of water this type of flume is the more economical, owing to the smaller quantity of lumber required.

At the lateral turn-outs from the main flumes, two cleats are nailed at each side of the lateral to form grooves into which the slide-gate may fit.

Galvanized iron surface pipe, 2 inches in diameter, is in limited use in bush-berry fields in the Sierra Nevada foothills, the pipe sections

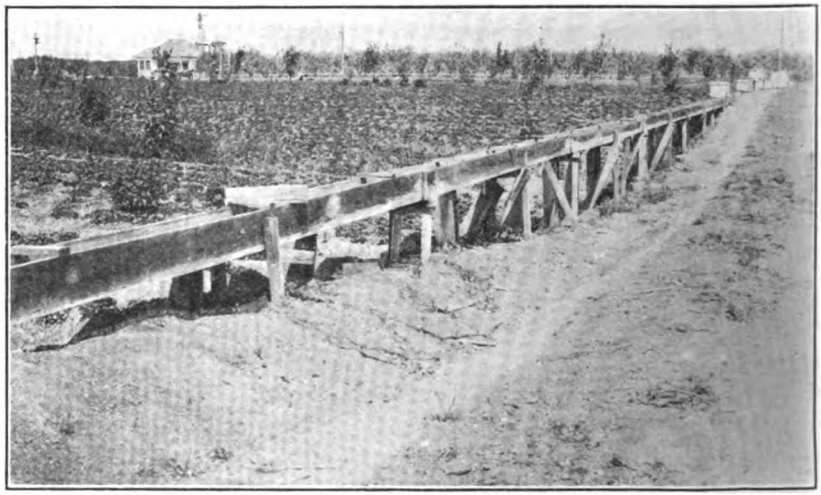

Fig. 5.—Flume trestle crossing swale. Simple wooden supports are used where the flume is close to the ground.

being disconnected as convenient and the water allowed to run into a small group of furrows at one time. Cast-iron pipe is likewise of limited general use, but is found locally in most of the berry fields in the Montebello district of Los Angeles County, where water is supplied under pressure from underground mains and the quantities used determined by meter. This pipe is commonly 2 inches inside diameter and is laid on the ground surface along the upper ends of the irrigation furrows, the flow into the various laterals being controlled by valves.

Some growers in the Moneta district of Los Angeles County have earth ditches lined with 1-inch by 12-inch lumber on the side nearest the beds, the lumber being held in place by stakes. This type of dis-

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tributary does not prevent seepage losses, but it prevents erosion of the sides of the furrows and better regulates the quantities of water turned into the furrows than if no facing were provided, at the same time eliminating two-thirds of the cost of a flume.

When earth ditches are used metal dams or tappoons are set in place for diverting the water into any desired number of furrows, and when these furrows have been irrigated the tappoon is carried farther down the ditch for the next set. Obviously it is necessary to close the heads of the furrows as they are watered. Sometimes short pieces of 1-inch iron pipe are laid through the ditch bank to admit water to the furrows. Small division boxes with slide-gates are placed at the junction of main ditch and laterals.

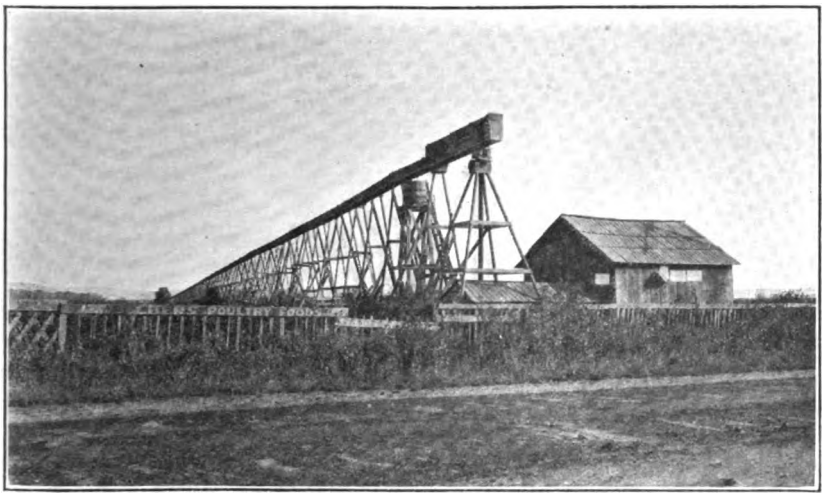

Fig. 6.—Flume trestle at pumping plant. When the pumping plant is located at a low point in the field or at some distance from the field, the trestle must be raised high enough to provide the necessary grade.

Water is released from the wooden flumes through holes or cuts of varying sizes (fig. 7). In Pajaro Valley and parts of Santa Clara Valley the holes are usually 3 inches in diameter, with the lower edges made flush with the bottom of the flume, and fitted with wooden plugs partially wrapped with cloth to insure tight fitting. Sometimes rectangular cuts are made, plugs for which are the pieces that were sawed out, wrapped with cloth. In parts of Santa Clara Valley and in southern California 1-inch auger holes are made in the side near the bottom, one hole for each furrow, and either wooden or cork plugs or hinged wooden doors are provided for regulating the flow. In the

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case of V-shaped flumes also, 1-inch auger holes are bored near the bottom and fitted with plugs or corks. With large heads of water two or three such holes are grouped for each furrow, this same practice being followed in earth ditches lined on one side with lumber as above described. To prevent washing, the outlets should be placed as close to the ground as possible.

Dams in rectangular flumes consist of short pieces of lath placed one above another on edge and made long enough to fit tightly into the flumes. Sometimes longer sticks are merely laid against the cleats, nailed at intervals across the flumes, particularly in the case of V-shaped flumes on account of their inconvenient shape (fig. 8). This

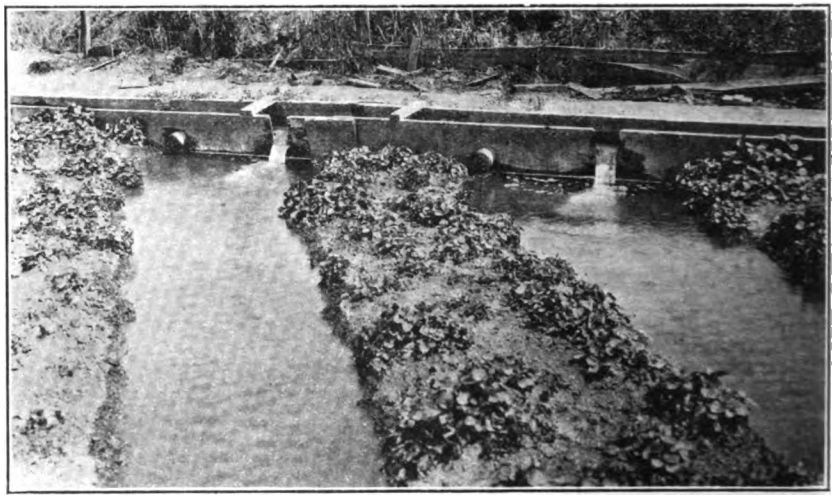

Fig. 7.—Irrigating from rectangular wooden flume. This shows the rectangular openings in the flume, and also the more commonly used circular holes fitted with wooden plugs.

is a makeshift practice, however, and at small additional cost it would be possible to have slide-gates at convenient intervals in either type of flume by cutting grooves or nailing cleats on two sides. These gates could be raised or lowered in a rectangular flume to permit the desired quantity of water to pass, and in case of a V-flume triangular gates of varying height could be used to allow for the desired overfall.

In the case of the cast-iron pipe used at Montebello, holes one-fourth to five-sixteenths inch in diameter, one for each furrow, are provided as outlets. These holes are fitted with wooden plugs. The flow of water in the pipes is controlled by valves.

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Assuming the length of furrows to be 200 feet and not counting main supply conduits, there will be required per acre for an average shaped tract about 525 board-feet of 1-inch lumber, of which 125 board-feet is for the 12-inch main flume and 400 board-feet for the 8-inch laterals. At $25 per thousand feet the cost of lumber will amount to about $13 and labor will cost about $6 or $7, providing the flume is laid on the ground, making the total cost of flume installed approximately $20 per acre. Any amount of trestle required will increase the cost correspondingly because of the added amount of lumber and greater expense of fitting. If water is conveyed from a pumping plant located outside the tract, as is often the case, there should be added to the above figures the proportionate cost of installing the flume leading from the plant to the tract, which will depend upon the added length of flume and amount of trestle-work required.

The cost of a 12-inch V-shaped flume will be about the same, but an 8-inch V-type installed under the same conditions will cost $14 or $15 per acre.

MAKING THE FURROWS

The types of furrow systems found in California berry fields are described later. Only the process of making them, which is the next step in the preparation of the field, will be considered here.

In Pajaro Valley, where the strawberry furrows are very broad, the general practice has been to make them with a shovel. On a pole some 30 feet in length are made pairs of marks representing the width of the furrows, with the distance between the pairs equal to that desired between furrows. The pole is laid down successively along the supply ditch or flume and stakes are set at each mark, and the process is repeated at the foot of the furrow spaces, usually 150 to 300 feet away. Strings or wires are then stretched taut from each head stake to its corresponding stake at the foot so that the furrows lie marked out on the ground. A man then goes down the furrow spaces with a shovel and throws alternate shovelsful right and left to equalize the furrows and ridges. The cost of this operation, including smoothing the ridges afterwards, is $15 or more per acre. More recently, however, in Santa Clara and Pajaro valleys horse-drawn implements for making ridges have come into use because of the smaller cost. A typical implement of this kind consists of three iron V-scrapers, the sides flaring outward toward the rear, these being fastened together, abreast, the desired distance apart, the whole hung from two wheels in front and from one at the back, and with two upright rachet levers for raising or lowering

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the "V's" with reference to the wheels (fig. 9). This implement is drawn by four horses, the driver standing on a platform at the back and adding his weight to the machine. This of course makes three furrows at one time. The ridges are subsequently properly shaped and smoothed with hoes and spades. Sometimes, however, the ridging is done with a disk-harrow drawn by two horses, the two disks on each side being set at such an angle that the earth is thrown into a ridge in the center, the finishing being done by hand. Other growers do the work with shovel-cultivators. A small shovel is attached to the back of a V-shaped cultivator, with ropes stretched to keep it in line, the teeth stirring up the soil and the shovel throwing it to both sides. Later

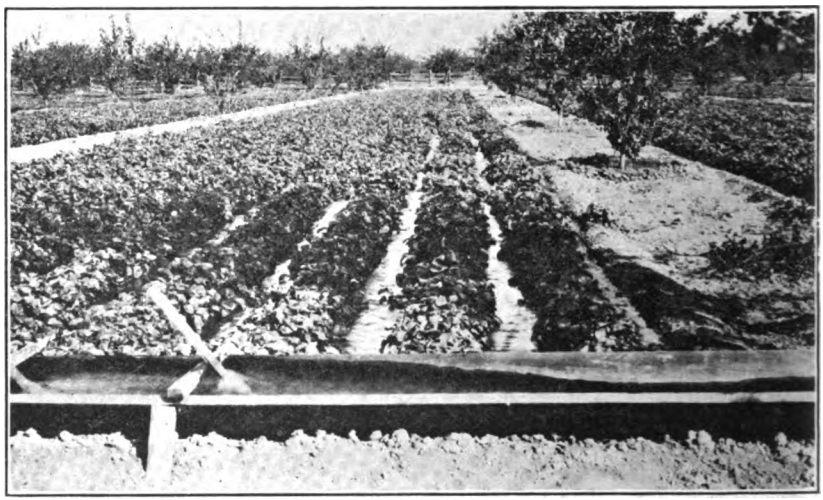

Fig. 8.—Irrigating from V-shaped wooden flume. The water is turned into the furrows through 1-inch auger holes near the bottom of the flume.

along the furrow thus marked out a broader shovel is drawn to widen and complete it, the ridges then being smoothed with hoes. This finishing work is facilitated in any case by stretching wires or ropes along the edges of ridges to mark the desired width and then working into them. The cost of these various methods ranges from $2 to $6 or $7 per acre. Their disadvantage as compared with the hand method lies in the difficulty in adhering to a perfect alignment, but the lessened cost is an important factor.

In some places the rows are measured at the head with a tape instead of with a marked pole. Marking the furrow centers is sometimes done with a wheel-barrow, though the liability of variation from

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a straight line is great. Again a sled, with runners adjusted to the proper width, may be used, and a variation of this consists in having the runners spaced twice the desired width with a chain dragging in the center to make the third mark. By moving this up and down the field with the outside runner following closely a mark already made, the proper alignment may be maintained.

Where the furrows are not so wide, but are deeper, they may be readily made with a one-horse plow by going back and forth along the mark to the desired depth. Very small furrows are sometimes made with a hand plow or even with a hoe. The ridges are thrown up to a greater height than is ultimately intended and later smoothed down.

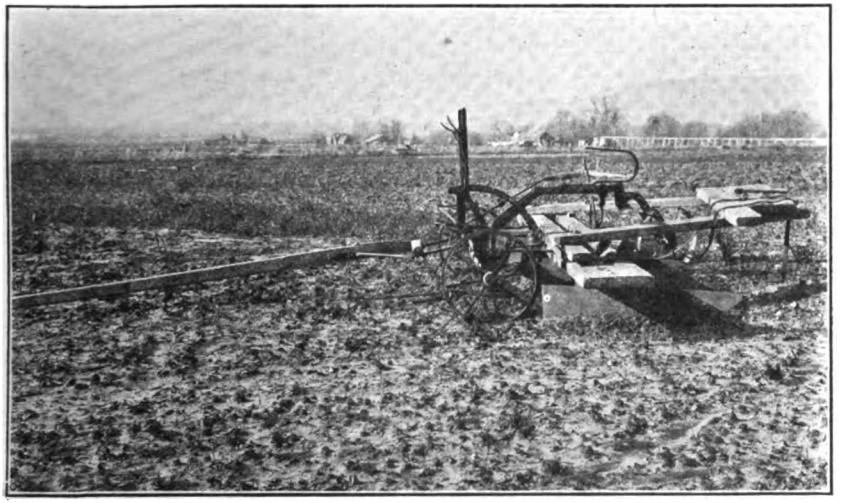

Fig. 9.—Ridger used in Irvington berry district. Each of the three "V's" scoops out a furrow. The implement is drawn by four or six horses.

This finishing may be readily done with a V-shaped ditcher or crowder adjusted to the final width of the furrow and having horizontal wings to smooth the surface of the ridges, which is the practice in the Florin and San Joaquin County sections. In the Moneta district of Los Angeles County the newly-made furrows are first harrowed with a V-shaped cultivator to prepare the furrow bottoms, and then a ridge smoother completes the tops and sides of the beds. This ridge smoother consists of three boards about 3 feet in length fitted together in such widths and at such angles that the completed form corresponds exactly to the desired shape of the ridge when completed. Being drawn by one horse and with the driver standing on it, this implement molds the ridges to their final form.

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There is also in use in the Gardena-Moneta section an ingenious scoop-scraper for the removal of minor irregularities in furrows (fig. 10). This scraper consists of a 2-foot section of 12-inch well-casing opened and spread into a semi-circle, blocked with wood at the back end and braced across the top with a stick at the front. At the back is a handle 2 feet long extending from the two sides, and attached to the block of wood is a very short handle, the former for bearing down and the latter for lifting. The implement is drawn by one horse. Sometimes the scoop is used before harrowing the furrows, and again not until water has been turned into the furrows and the small irregu larities in grade are more discernible. Very small quantities of eartl

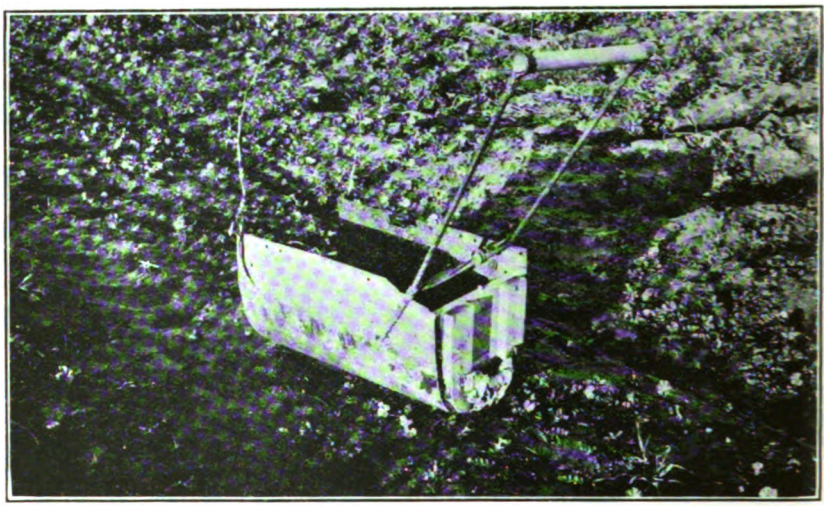

Fig. 10.—Scoop-scraper for furrows. This is used for correcting minor irregularities in the grade of furrows. The long handle is for bearing down, and the short handle for lifting. It is drawn by one horse.

may be easily handled in this way and a more nearly perfect grade secured.

Provision is usually made for dams of some kind in the furrows where the soil is too heavy to permit of rapid penetration of irrigation water and where the grade is such that water might run off too rapidly. In some cases these dams or checks are of soil, often covered with newspapers or cloth to prevent their washing away, and placed every 60 to 80 feet or more apart in the furrows, serving to hold back the water and to permit it to soak into the ditch banks (fig. 11). Again a wooden dam may be used, with a piece cut from the top to permit water

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to flow over into the next section (fig. 12). The washing of the soil caused by falling water may be avoided by imbedding a few stones close to the dam. These checks are used only in large furrows having some grade where considerable quantities of water are turned in, and have no application to the practice of making small furrows and turning into them only enough water to reach the ends.

The construction of a small drain or run-off ditch is necessary at the ends of furrows where the soil does not absorb rain water as it falls and where consequently there is danger of flooding. There is less liability of damage from this source during the irrigation season because of the possibility of regulating the amounts of water in furrows; hence the ends of the furrows are opened in winter and closed in summer.

With the completion of the ridges and furrows the field is ready for planting.

TRELLISES

Bush berries of the trailing type are trellised, and even those of the upright type are usually provided with some form of support because of the weight of the canes when loaded with fruit. The trellis consists of posts 2 inches by 4 inches, more or less, in dimension, 3 to 5 feet high, and set from 10 to 30 feet apart, with double wires stretched one above another or abreast. Such trellising costs from $10 to $25 per acre in place, depending upon the extent of vegetation and resulting strength of materials necessary to support it.

SETTING PLANTS

In setting strawberry plants a spade, dibble, or trowel may be used. Often a line is stretched along the bed at the proper distance from the side and the planter goes along this, estimating the distance from plant to plant. In sections where very small furrows are made the plants are sometimes set out before the furrows are made. A marker is used in San Fernando Valley consisting of a number of thinly-sharpened pegs projecting downward from a timber at intervals corresponding to the distance between the rows, with a handle in the center, and all usually of very light construction. This is drawn down the field by a man to mark out the plant rows. After setting the plants the furrows are made with a hand plow. In some instances plants are set out in a trench made by a plow. Bush berries are set in holes made with a spade or in a trench, and if regularity of spacing is desired the distances are measured.

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Setting out the strawberry plants costs $8 to $10 per acre. The plants themselves vary in price, from $2 up to $15 or $20 per thousand. Most of the varieties grown commercially in California cost from $2 to $6 per thousand. The number of plants originally set per acre ranges from 12,000 to 18,000 or 20,000, and the acreage cost for plants usually ranges from $20 to $50, because reductions may be made when plants are supplied in very large quantities. Setting out bush-berry plants costs about one-half as much as setting out strawberries. They are spaced farther apart and fewer plants are used—about 800 per acre for blackberries, up to 2500 for raspberries and currants, with loganberries and dewberries at intermediate figures. The California

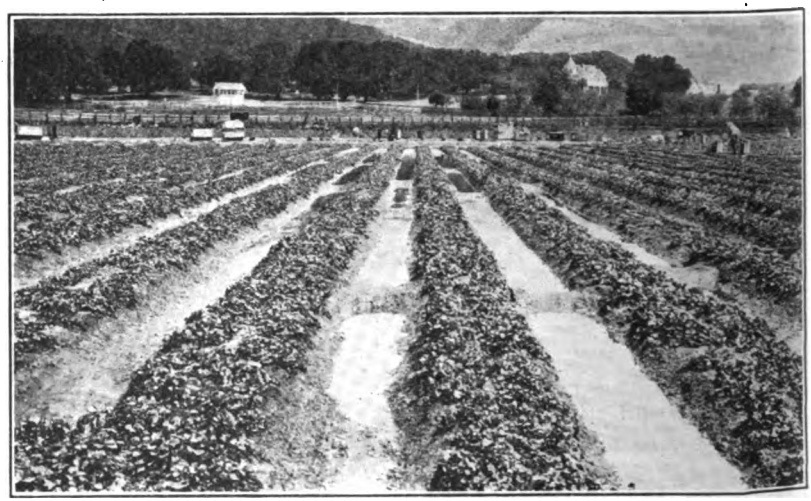

Fig. 11.—Earth dams in furrows. These are placed at intervals to hold back the water where the grade would otherwise cause it to run off too rapidly.

bush-berry varieties range in price from $5 to $35 per thousand, making the acreage cost from $20 to $60 for plants, or about the same as for strawberries.

FURROW SYSTEMS

Only one method of irrigating small fruits is in use in the commercial berry centers of California, and that consists in applying the water in furrows. As a rule the plants are set on raised beds or ridges and the water is allowed to seep into the sides, but in a few places the berry plants are placed on the general level of the field and the water

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is run in very small furrows made after planting. There are of course some exceptions to the one general method of irrigation. For instance, in the southern part of the state a few growers of nursery stock and berries, vegetables and berries, and small fruits and flowers are using spray systems of irrigation, but for small fruits alone such systems have not at this writing come into extended use in commercial plantations in California. The depressed-bed method, in which the plants are grown on level areas inclosed by levees along the tops of which small irrigation ditches are run, although found in truck gardens near the large cities, does not appear in strawberry fields at the present time.[1]

Fig. 12.—Wooden dam in furrow. The cracks in the soil are the result of failing to cultivate after irrigating.

Within this general method of irrigation by furrows are the two divisions spoken of above, the raised-bed and level-planting systems, and the former may be further subdivided into three classes for strawberries and two for bush fruits, differing mainly in the relative locations of furrows and berry rows. These have been termed the single-row system, the matted-row system, and the double matted-row system of irrigating strawberries, and the single-furrow and double-furrow systems of bush fruits. Thus the differences in the strawberry systems relate mainly to the width of the beds and consequent character of plant rows on the beds between furrows, and in the bush-berry

[1] The merits of various methods of garden irrigation are discussed in U. S. Dept. Agr., Farmers' Bull. 138, "Irrigation in Field and Garden."

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systems to the number of furrows between plant rows. Within these groups are also variations in dimension. Whenever the term "bed" is used herein it is taken to mean the ridge between two furrows.

Furrows in berry fields are usually 200 to 250 feet in length. Often they are made level from end to end, or again are given a grade of upwards of 3 inches in 100 feet. Where large heads of water are turned in and the desire is to fill the furrow and to allow the standing water to seep into the sides, the only purpose subserved by a grade is to induce rain water to run off where the soil does not absorb it readily, and in such case dams as described on page 14 must be placed in the furrows at intervals to hold back the irrigation water. Where the soil is sufficiently porous to absorb rain water the level furrow is preferable. Small furrows in which very small streams are to be run are laid on a grade in order to permit the water to reach the ends.

FURROW SYSTEMS FOR STRAWBERRIES

The raised-bed method is by far the more prevalent of the two practices and in the following descriptions its several subdivisions will be given equal weight with the level-planting system.

Single-row system.—This is probably less in use than either of the other raised-bed systems and certainly less than the ordinary double-row system. Fields are laid out on this plan in Los Angeles and Orange counties, Santa Clara Valley, at Galt in Sacramento County, and doubtless elsewhere. In one field of this type visited the furrows are 2 feet apart from center to center, and the ridges and furrows are of equal width, the furrows being about 6 inches deep. The distance from center to center of beds is sometimes 22 inches, or as much as 34 inches, in the latter case the width of the furrow exceeding that of the ridge, which is an uneconomical practice because of the lessened area given to the plants. The depth of furrows likewise varies. It is seldom greater than 6 inches under this system, but is often only 3 or 4 inches, the determining factor being the water supply available and the head to be run in each furrow.

Very often the plants are grown as "singles;" i.e., all runners are cut off as they appear and only the original or mother plants are allowed to grow. Sometimes one runner plant is set between adjoining originals, however, especially where the latter are planted far apart. This distance between plants is governed by the variety and by the financial means of the grower. Varieties that make large plants and that produce many runners require greater spacing, and a grower

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whose means make imperative as small an initial outlay as possible usually buys a minimum number of strawberry plants and depends upon the runner plants to supplement the stand. Consequently this original spacing is found to vary from 6 inches to 4 feet. In a large field at Strawberry Park, Los Angeles County, plants were set out 4 feet apart in the center of the bed in the first instance and two rows of four runner plants each were made between adjoining originals, resulting in an ultimate distance of about 10 inches between plants.

In soils which permit of limited lateral penetration of irrigation water this single-row system is preferable because of the narrower beds and greater opportunity for irrigation water to reach the plant roots from the two furrows. Objections made by some growers are that the greater proportion of wetted surface gives more opportunity for baking and that the narrower ridges dry out too quickly; also that in very light soils the sides of the ridges are eroded and plant roots thus exposed to injury. The first objection may be partially overcome by cultivation, and the second is not serious in heavier soils. On the other hand, an advantage of the narrower beds lies in the greater area that may be cultivated with a horse and the consequent elimination of much expensive hand work.

Matted-row system.—The matted-row system differs from that just considered in the greater width of beds between furrows and the covering of the beds with plants instead of limiting the plants to one row on a narrow bed. This is the most widely used method found in California for strawberries. It is universal in Pajaro Valley and is largely in vogue in Santa Clara Valley and southern California. The field shown in figure 13 is a typical Pajaro Valley field of this class. The ridges or beds are spaced 54 inches from center to center, the ridges 32 inches wide, and the furrows 22 inches wide and from 3 to 6 inches deep. The beds are level from side to side. The furrows vary in length from 150 to 300 feet, 200 feet being probably most general. At the end of a bed of such length another supply flume heads another similar bed.

In the matted-row system the plants are originally set out in double rows on each bed, the rows being 20 inches apart and the plants 10 to 22 inches apart in the row, depending upon the variety. For instance, Malindas are usually spaced 10 or 12 inches apart and larger varieties like the Klondike about 20 inches. From these mother plants all runners are cut off during the first year, except two or three which are set to fill the intervening spaces, thus giving a single matted row on each bed and covering the entire ridge with foliage.

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There are variations from these dimensions, however. Sometimes the distance from center to center is only 42 inches. In many parts of southern California the distance is 36 inches, with the ridges and furrows of proportionate width, or about 21 and 15 inches, respectively. In other places the distance from center to center is 34 or even as short as 28 inches. The 54-inch dimension is followed in parts of Santa Clara Valley.

In Pajaro Valley there is a considerable area of hillside plantings where the rows follow the contours. The distance from center to center of furrows is greater than in level fields, being 66 inches usually, or a foot greater. The slope of the ridges from side to side is greater than

Fig. 13.—Strawberries under matted-row system. Two rows of plants are originally set out along each bed and the runner plants fill the intervening spaces, making finally one matted row between two irrigation furrows.

the general slope of the hill and the ridges are banked up so that the furrows are level and symmetrical from side to side. It is quite necessary that the upper side of each bed should be well banked, else in cultivating the furrow, soil will be thrown down upon the plants. These hillside plantings are satisfactory where the soil is good and where it is carefully prepared, and, also, where there is good underdrainage.

The matted-row system with its greater width of beds has the advantage of a smaller number of furrows to take care of. It is adapted to soils where conditions are favorable for lateral penetration of water by capillarity or because of an underlying hard stratum, and

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the beds should not be made so broad that the moisture from the two furrows is unable to meet within a short time after irrigation.

Double matted-row system.—The points of difference between this system and the ordinary matted-row system just described are the division into two independent rows of plants on a bed, the resultant greater distance between irrigation furrows, the greater depth of furrows, and the differing functions of the alternate spaces between plant rows. Figure 14 represents a typical field of this type at Lodi, in San Joaquin County. The distance from one furrow center to another is 6 feet, and the furrows are 12 inches deep. The plants are originally set out in double rows 3½ feet apart and 1 foot apart in the row. From each of these plants two to three or four runners are made to take root, largely set in from the furrow side, although some plants hang out over the furrow. When the two parallel rows on a raised bed have completely formed there is a bare space some 18 inches in width between. The result of this system is parallel matted rows 3 feet apart from center to center, with irrigation furrows and level bare strips in alternate intervening spaces. The purposes of these two classes of intervening spaces are altogether different; that is to say, the furrows are used for carrying water only, whereas the bare strips on the beds are cultivated, instead of the furrows, and they further serve as paths for pickers to walk in. The furrows are made quite level from end to end, and about 100 feet long. In some of the fields the distance from center to center of furrows is 5 feet instead of 6, and in other localities it is as great as 7 feet.

An adaptation of this system to an inter-cropping of berries and vines is found in the Florin district, in Sacramento County, and is practically universal there in berry fields. The strawberries are incidental to the vineyard and are planted in order to provide an income while the vines are maturing. The grape vines are set 8 feet apart each way and the irrigation furrows are 1 foot from the vines, but are only made on one side of them. Thus the distance from center to center of furrows is 8 feet. The furrows are 12 to 18 inches wide and 1 foot deep. On each side of the "lands" between the vines a row of strawberry plants is set out, one of these rows being directly in line with the vines. The plants are placed upwards of 32 inches apart in the row, and from these original plants six or seven runner plants each are formed. The result is the same as in the Lodi, or double matted-row system just described, with a bare space of some 18 inches between the two resulting rows on each bed. Sometimes the strawberry plants are set closer together in the rows, say 14 to 18 inches apart,

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and fewer runner plants are allowed to take root. The number of plants originally put out, as heretofore stated, is usually dependent upon the means of the grower. The beds in the Florin section run east and west and the vines occupy the north edge of the beds, in order to give the greater sun exposure to the berries. It is the experience of growers that the strawberry plants along the south edge produce from two to two and one-half times the quantity of fruit that is taken from those on the north.

The double matted-row system, with its variation in use at Florin, is especially adapted to porous sandy soils overlying hardpan or heavy clay subsoil, for rapid lateral percolation is assured and evaporation

Fig. 14.—Strawberries under double matted-row system. Two independent rows of plants are formed on each bed between furrows. The furrows are only for irrigating, and the bare space between plant rows on the raised bed is for cultivating and picking berries.

losses are likely to be small, owing to the smaller cross-section of the furrows. The system has an added practical value in affording a dry place for pickers to walk while water is running in the furrows. In a field of this type at Florin a boring made in the exact center of a bed one week after irrigation disclosed an abundance of moisture above the hardpan, which was 30 inches from the surface at this point, thus indicating that where such soil conditions are encountered an extra furrow through the center of the bed is unnecessary. However, in a very heavy soil where capillary movement is sluggish, or in a soil so porous that lateral penetration of water is limited to a few inches, this system would doubtless be found inadequate.

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Level-planting system.—Under this system no raised beds are made, but the plants are set out on the general level of the field and small furrows are afterwards made with their tops higher and bottoms lower than the surface around the plants. The essential difference between this and the raised-bed method is that with the former the furrows may be destroyed by cultivation and if so must be remade before another irrigation, thus permitting flat culture, whereas in the methods heretofore considered the beds and furrows are made permanent during the life of the planting.

The level-planting method is not in wide use. Instances of it are found, however, in Sonoma and Placer counties, and in San Fernando Valley. In the foothills of Placer County the furrows are run directly down the slope of the hill, unless the latter is too steep, and are placed close to the plant rows. Where the ground slopes laterally also, the furrows are run on the upper side of the rows rather than below them. The plant rows are usually spaced 36 inches from center to center and the plants are grown as "singles" 12 to 16 inches apart in the row. The furrows are about 4 to 6 inches wide and 2 inches deep, and unless cultivated down and renewed from time to time erosion tends to increase their depth. This method is also found on level lands in San Fernando Valley. The plants are set in single rows 19 to 20 inches apart and about 11 inches apart in the rows, with a furrow 9 inches wide and 3 inches deep directly between the rows. In Sonoma County under favorable conditions strawberries are often unirrigated, being laid out in single rows 3 feet apart and upwards of 18 inches apart in the row, on a flat-culture basis.

FURROW SYSTEMS FOR BUSH BERRIES

Owing to the much greater distances bush berries are set apart, the question arises, not as to how many rows of plants to place between two furrows, but what number of furrows to use between plant rows.

Single-furrow system.—Where only one furrow is used between plant rows on raised beds it is usually broad and shallow. Where the rows are 6 feet apart from center to center the raised ridge is about 2 feet wide and the furrow is 4 feet wide and 4 inches deep, and level from side to side. An advantage claimed for this is the elimination of a dry area in the space between rows. The spreading of the water in a thin sheet, however, increases the danger of evaporation losses. This method is found in parts of southern California.

There is considerable variation in the distance between bush-berry plants, ranging for blackberries from 3 to 8 feet apart in rows, and

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from 5 to 10 feet between rows. Probably the average distance for the most widely grown varieties is 6 by 8 feet. Dewberry bushes average 4 feet apart in rows which are 7 feet apart. The average practice for loganberries is to set them out 5 feet apart in rows 6 feet apart, although practice varies in different localities and with different soil types. Raspberries are usually planted closer together in the rows, generally 3 feet, and about 6 feet between rows. Gooseberries, which are grown to a very limited extent in California, were set 4 feet apart in rows 6 feet apart in the few instances noted, and currants about 2½ by 4½ feet.

Fig. 15.—Young loganberries under double-furrow system. The intermediate ridge between plant beds provides a dry path for pickers while water is running.

Double-furrow system.—The use of two irrigation furrows between rows goes with growing the bush berries on raised beds. The furrows, which are small, are made close to the plant rows and between them is a low ridge which provides a dry path for pickers to walk on while irrigation is in progress. In a typical field where the plant rows are 8 feet apart, the main plant ridges are 2 feet wide, intermediate ridges 3 feet wide, and furrows each about 18 inches wide and about 8 inches deep. The subsidiary ridge lies several inches below the surface of the plant beds. This system, which is very general in southern California, is better adapted to wide spacing of plant rows than is the plan of having one broad furrow, because of the necessarily great width of the latter, and the greater heads of water necessary; and by having

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a furrow on each side of the ridge the plant roots are more generously supplied with water than in the next method considered.

Level-planting system.—In connection with setting bush berries on the general level of the field one small furrow is often provided for their irrigation. This is placed close to the row on one side or the other. The furrow is usually made 12 to 18 inches wide and about 6 inches deep. This is the plan generally followed in sections with more abundant rainfall than that of southern California and where less irrigation is required. In the Placer County foothills the rows are usually run directly down the slope, with a furrow 4 inches wide and 2 inches deep close to each row. Where bush berries are not irrigated, as in Sonoma County and parts of Santa Cruz County, no attempt is made to grow them on raised beds.

APPLICATION OF WATER

The water supply for berry irrigation must be a dependable one throughout the dry season and particularly while fruit is being produced. This applies in greater measure to strawberries than to other small fruits because bush-berry plants are the more drought resistant. Only small quantities of water are needed for strawberries at any one time, but it is needed often, and the lack of water for a protracted period during the summer may prove fatal to the plants or at least impair their crop-producing powers for another season. Hence the commercial strawberry grower whose field is located under a canal system with erratic water supply often needs to supplement such supply with a pumping plant.

As a matter of fact pumping plants furnish most of the water used in the large berry centers of California. They are usually small plants, for the acreages and heads of water used are small.[2] In the foothills of Placer County gravity water is used, delivery being continuous to each irrigator throughout the season and thus favorable to berry irrigation.[3]

The amount of water applied to strawberries under present practice in California is much greater than that applied to bush fruits. Strawberries bear for a longer time each year and are shallower rooted, and although the frequency of application could be lessened by more attention to the advantages to be derived from cultivation, nevertheless the

[2] For the size and cost of a pumping plant for a given acreage, see Cal. Agr. Exp. Sta. Cir. 117, "The Selection and Cost of a Small Pumping Plant."

[3] For a description of irrigation conditions in this section see Cal. Agr. Exp. Sta. Bull. 253, "Irrigation and Soil Conditions in the Sierra Nevada Foothills, California."

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moisture in the limited feeding zone of the roots requires more frequent replenishment and the plants are more ready to show signs of distress.

STRAWBERRIES

Strawberries require ample moisture in the soil constantly during the growing season and particularly while bearing fruit; hence it is obvious that varieties with a long bearing season need more water over a longer period than so-called "one-crop" berries, for after the latter have ceased to produce fruit they need less for the development of the plants alone. As the root system is usually confined to the first 12 or 14 inches in depth and seldom extends below 18 inches, the upper 2 feet of soil must be kept moist. Hence arises the necessity for frequent light applications of water in amounts sufficient to replace moisture lost by evaporation and withdrawn by the plants, but not for so great a supply of water that an excess is permitted to seep beyond reach of the roots. Ordinarily in practice no particular test other than dryness of the surface soil and a brown tint to the leaves is used to determine when this need for irrigation exists. Many growers believe that the supply of berries increases with the amount of water applied, and due to this belief comparatively few plantations are found where with an ample water supply at hand the plants are allowed to reach a stage of distress at any time during the year. Although too little water causes the berries to be few and small, an excess often renders the fruit soft and unfit for long shipment. In some sections of California, notably the Sebastopol district of Sonoma County, many strawberry fields are not irrigated. Conditions making possible strawberry production without irrigation in the Sebastopol district are the heavy winter rainfall and soil conditions favorable to the retention of moisture during a large part of the dry season, but yields are reported to be lighter than those from irrigated fields, and in a dry autumn the plants suffer and are rendered less productive the following season. Yet for economic reasons, such as the high cost of irrigation and difficulty of competing with certain other sections, irrigation is often locally considered not justified.

Where strawberry plants are grown on raised beds, which as before stated is the common practice in California, it has been found that the entire ridges must primarily be wetted, but that it is not well for the surface of the ridges to be kept damp because fruit coming in contact with damp soil usually spoils, and further because such surfaces on drying tend to become baked or checked. The crust may of course

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be broken by hoeing, but it is obviously unnecessary and undesirable to start with. Consequently in order to wet the ridges thoroughly without moistening the immediate surface layer, the practice is to carry the water in the furrows almost to the ridge tops and to depend upon lateral seepage and capillarity to distribute the moisture throughout the ridges. To be able to run the water in this way a very careful preparation of the land is essential (see p. 2).

The number of furrows watered at one time is dependent upon the method of irrigating and upon the head available. That is to say, if the method is to fill the furrows quickly, to take the head elsewhere, and to allow the standing water to seep into the banks, the number of furrows a single head is turned into is not so great as if it is allowed to run into the furrows for a long time and to feed slowly into the soil. The former practice is followed in sections like Pajaro Valley and Sacramento County where capacious furrows are the rule. With heads of water of 90 to 200 or 300 gallons per minute some three to nine furrows are watered at one time and the amount turned into each furrow ranges from 10 to about 30 gallons per minute. The number of furrows is sometimes changed to suit the convenience of the irrigator. If he has other work nearby he doubles the number of openings in the flume and thus secures more time between changes from one set of furrows to another. With this method it is necessary that the furrows be level from end to end, or else that dams or checks be placed at intervals to hold back the water, as shown on page 14, in which case a fall of 1 to 3 inches is given in 100 feet of length. Level furrows are desirable only in well-drained soil.

The method of running the water for long periods of time in small furrows is followed in Placer County and in some other sections. With a stream of 30 gallons per minute upwards of twenty-six furrows are watered at one time, with thus about 1 gallon per minute in each furrow, and the same ratio holds good for smaller heads. Usually the amount is gaged by the quantity necessary to reach the end of the furrow without waste, and this quantity once established is permitted to run for 12 hours or more. Some very steep slopes are irrigated in this way. On fairly heavy soil near Galt, from thirty to sixty furrows are watered at one time with a head of 90 gallons per minute, or 1½ to 3 gallons per minute in each furrow. The grade is approximately 1 inch in 100 feet. The water is run for about 10 hours in each furrow. In San Fernando Valley on sandy loam soils with but little grade, upwards of sixty furrows are sometimes supplied at one time with a reported flow of 60 miner's inches and the water run for a long time.

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The irrigation season extends in most places from the cessation of spring rains until some time in the fall. If the dry season is protracted in the fall, late bearing varieties are irrigated sometimes until December, but plants that have ceased to bear are usually not watered so late. Conditions are different in most sections of California from the mountain states where the season is much shorter than here and where irrigation must be suspended to permit the plants to go into dormancy before freezing weather sets in. The frequency of applying water varies from time to time during the season. Factors governing this in practice are the length of the bearing season, the weather, and the convenience of the irrigator. In general, irrigation occurs most

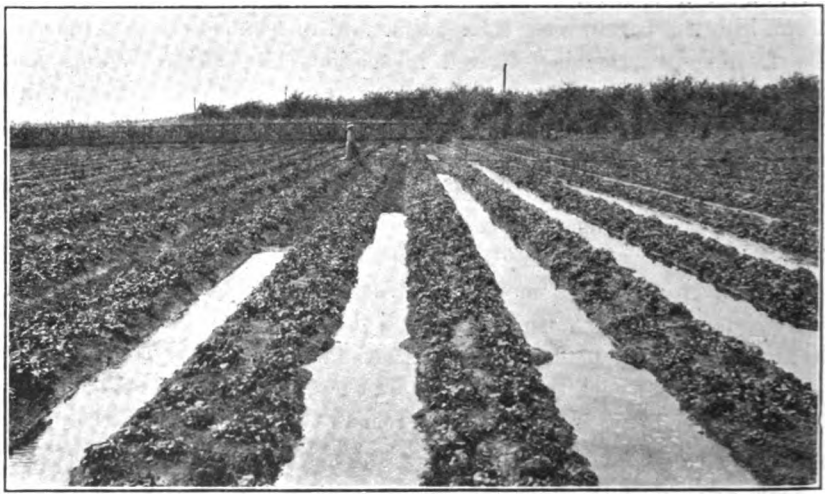

Fig. 16.—Irrigating strawberries under matted-row system. Water is turned into three to nine of these large furrows at one time.

frequently during the summer months when the bearing season is at its height and hot weather is prevalent, and as pickings then occur oftener the applications are often timed to follow them immediately. According to different practices the intervals at which the field is irrigated depend also upon soil type and frequency of cultivation.

In Pajaro Valley the usual practice is to irrigate immediately after picking, which means every ten days or two weeks in early spring and in the fall months, and every week at least during the summer. No particular test governs the time of irrigating, but it is largely a matter of convenience. However, if a particularly hot spell occurs during the summer more frequent irrigations are the rule, sometimes as often as

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every four or five days. A great many days in summer are foggy and in some cases this has its effect on the frequency of irrigation, for the soil naturally remains moist a greater length of time and longer periods are allowed to elapse between waterings. Some growers in this section irrigate the lighter soils every week and heavier ones every two weeks.

The practice in the San Juan section of San Benito County closely follows that in Pajaro Valley.

In Santa Clara Valley strawberry fields are irrigated each week in summer and every two weeks in spring and fall.

At Galt, in Sacramento County, on heavy retentive soils the irrigations are comparatively few, averaging eight times in a season, or every two weeks during hot weather. In the Florin district of this county, however, on lighter soils berry fields are irrigated as a rule every week through the hot weather and every ten days when the weather is cooler. The San Joaquin County practice is the same. If the weather is unusually hot or if a north wind is or has been blowing, waterings often take place at intervals of four or five days.

In Placer County strawberries are not irrigated much before the fruiting season, but while the plants are bearing they are watered about twice each week. After the first crop no more water is applied than absolutely necessary to keep the plants alive until about two weeks before the second crop comes on, when frequent irrigations are resumed.

In typical sections of Orange County heavier soils are irrigated every ten or twelve days throughout the dry season and lighter sandy soils more frequently, sometimes each week. During the fruiting season water is sometimes applied every five days.

In the Burbank section of Los Angeles County on sandy loam soil the water is applied as often as every second day during the fruiting season. In San Gabriel Valley on light soil it is applied every four or five days. In the Gardena-Moneta district strawberry plantations on heavy clay soils are irrigated each week or ten days, and on light soils twice a week in the summer and less often in spring and fall.

In some southern California districts growers follow the practice of irrigating in alternate furrows and picking from the dry furrows at the same time. At Montebello, for example, one grower irrigates every three days, turning the water at one time into one set and the next time into the other, and has his pickers in the dry furrows simultaneously. This amounts to a complete irrigation and picking every six days. The same practice is followed by some berry growers in the Moneta section and elsewhere.

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To sum up, light soils generally are irrigated at intervals of three to seven days in summer and ten to fourteen days in spring and fall, and heavy soils every week or every two weeks in hot weather and less frequently when cooler.

First-year plants require less water than older ones. They are smaller and the amount of fruit produced is slight—barely sufficient to pay for picking. Still some growers irrigate fully as much during the first year as later. Sometimes young plants are irrigated as frequently as older ones but with less water, the water being run only in the bottoms of the furrows. The time of applying the first water depends upon whether plants are set out early or late.

The duty of water for strawberries under present practice is found to be low as compared with most staple crops, being estimated to range from 3 to 5 acre-feet per acre in most of the important centers of the state. In some places by judicious use and conservation of water the seasonal depth is kept below 36 inches, but the general practice seems to be to apply more. Individual applications are necessarily light, ranging from 1½ to 2 or 3 inches in depth per irrigation and averaging probably 2 inches. Thus with the depth applied at each irrigation remaining practically constant at a figure which it is difficult to lower as a practical undertaking, the question of increasing the duty of water apparently becomes one of limiting the total number of irrigations in a season.

In a farming industry which involves the application of so much water as strawberries the problem of drainage assumes importance. Low-lying heavy soils are apt to become waterlogged sooner or later, which of course means poor plants and diminished yields of fruit, if not loss of plants absolutely and injury to the soil structure. Surface drainage during the rainy season is also necessary to avoid flooding the plants, and to take care of this and also any excess of irrigation water small drainage channels are often provided at the ends of furrows. Sometimes excess irrigation water is utilized by being carried into other furrows.

BUSH BERRIES

Bush fruits differ from strawberries in their irrigation needs in that they are deeper rooted and thus can draw upon a greater depth of soil; hence are better fitted to withstand periods of drought. In some sections of California they are not irrigated at all—in the Sebastopol district, for example, where there are very extensive plantings of blackberries and some of loganberries. With soil conditions

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favoring the retention of moisture and with proper cultivation the rains of the winter seem to prove sufficient for a year's production of these berries. In the cool bay climate of Alameda County currants are produced likewise without irrigation. In some other sections, however, where bush berries can be and are grown without irrigation, the growth of the plants and the quantity of fruit are often increased with artificial applications of water to such an extent that increased profits justify the installation of irrigation systems.

The time when blackberry, raspberry, loganberry, and other such plants need moisture mostly is while forming fruit, and after the bearing season is over a small amount suffices to maintain the plant growth. If the moisture supply is short the fruit tends to be small, dry, and seedy and the yield is reduced. Owing to the fact that bush berries can survive a deficiency in water supply with less injury than can strawberries it is sometimes the custom of bush-berry growers in years of poor market returns to apply no more water than necessary to keep the plants alive and to make the best of diminished yields.

The irrigation season usually extends from late spring to some time in the fall, depending upon the beginning of winter rains, though after the fruiting season waterings are very infrequent. Plants in their first year require and are given less water than later, and the intervals between irrigations are more frequent during hot weather than in spring and fall.

In Pajaro Valley all bush berries are irrigated except in favored spots, such as those occupying sedimentary bottom-land soil adjacent to a hillside where a sufficient amount of moisture seeps down from the upper levels to replenish the supply below. Blackberries are irrigated once or twice before the blossoms drop, then every ten days to two weeks during the picking season, and once or twice thereafter, depending upon the lateness of fall rains. Sometimes they are irrigated as frequently as each week during the fruiting period, but the two-weeks interval more nearly represents the general practice. The time and length of the picking season of course depend upon the variety. In southern California the practice is generally the same during the picking season, and irrigation continues less frequently than before up to the time rains start and begins again with the cessation of rains in the spring. In some situations, such as on heavy soils near Moneta, irrigation takes place only once a month throughout the dry season, and on lighter soils it may take place twice each week while picking and every two or three weeks before and after. In Placer County blackberries are irrigated once or twice a week during the

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fruiting season and several times while the plants are not in bearing.

In most sections of California dewberries are given practically the same irrigation treatment as blackberries, although in some sections in the southern part of the state, particularly on light soils, they are irrigated more frequently than blackberries under the same conditions. Being more shallow-rooting than many blackberry varieties they are more dependent upon irrigation.

Loganberries are in most sections given about the same amount of water as are dewberries. In Pajaro Valley, where many are grown, they are watered every two weeks from the end of the winter rains until the close of the fruiting season, and once or twice after that.

Fig. 17.—Young loganberries, recently irrigated with single furrows. The plants are set out on the general level of the field and the furrows are made later.

Sometimes they are irrigated more frequently while bearing fruit. The practice is similar in southern California, with often a greater seasonal application of water. Some growers irrigate alternate rows each week and pick from the unirrigated rows. Others in light soils irrigate every three or four days during the fruiting period.

Raspberries, as a rule, feel the effect of drought more quickly than blackberries. In southern California, where many are grown, the general practice is to irrigate every week during the fruiting season and every two to three weeks during the non-fruiting season in dry weather. In Santa Clara Valley the practice is about the same. In Placer County the practice is similar to that governing blackberries.

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viz., to irrigate every three to seven days during the fruiting season and several times thereafter.

As before stated, gooseberries are found in only a few localities in California. Those grown in San Joaquin County are irrigated every ten days in the spring and until the crop has been removed, then about every two weeks through the summer and less frequently in the fall.

Adequate drainage is fully as essential for bush-berry fields as for strawberries, but the danger of waterlogging the soil is generally not so imminent owing to the lesser quantities of water applied.

MOISTURE CONSERVATION

The problem of conserving irrigation water in the soil is deserving of more attention from small-fruit growers than it often receives, for it involves not only economy in the application of water, but the maintenance of proper soil conditions as well.[4] The objections growers make to summer cultivation of strawberries are that the dragging of a harrow along the furrow tends to raise more or less dust, which impairs their marketability if it settles on the low-lying berries in any quantity; and, furthermore, that berries that may hang over the side of the ridge are bruised by the cultivator. For these reasons the harrow is kept out of the field as much as possible while fruit is being picked. A good mulch is usually kept on the tops of the ridges, but their area is less than one-half of the total, and is the only ground to which water is not directly applied. It is the wetted sides and bottoms of the furrows that are most in need of frequent cultivation.

The effect on the soil of failing to cultivate furrows in a strawberry field is shown in figure 12, page 17. The shrinking of the soil on drying produced large cracks through which moisture was lost, a condition which would have been prevented by harrowing or hand hoeing after irrigation. In this instance the soil was a fairly heavy clay loam, and the baking would not have been so pronounced in a lighter soil. From the standpoint of water application alone, frequent cultivations during the growing season are of considerable economic importance in that they decrease the amount of water required and consequently the cost of water, a factor which looms large in many sections of the state. The cost of cultivating is partially offset by the lessened cost of applying water. On the whole it would appear to be questionable whether, under ordinary circumstances, those growers

[4] Dr. C. B. Lipman attributes the apparent decrease in productive capacity of Pajaro Valley strawberry soils to the fact that water is applied too frequently and proper cultivation neglected. See Cal. Agr. Exp. Sta. Cir. 122.

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who entirely dispense with summer cultivation can balance their gains against this higher water cost and lessened soil productivity caused by excessive applications of water.

Summer cultivation of strawberry fields is most generally found in southern California, where in some sections the furrows are harrowed after every irrigation, for it is recognized that moisture may be more effectively retained in the soil by so doing. In order to avoid bruising the berries the harrowings are often timed to take place immediately after ripe berries have been picked, as the damage to immature fruit is not so great. This practice is not universal in the south, however, for many growers there cultivate only in the spring. In some sections of the state where water is plentiful, the furrows are cultivated thoroughly before and after the fruiting season and between crops if possible, and frequent waterings are depended on to keep the soil loose during the picking season. This is the general practice in Pajaro Valley. Where this practice is followed the tops of the beds are hoed frequently to prevent weed growth and to maintain a surface mulch 1 or 2 inches deep. Care is taken in hoeing to keep away from the plants, for the roots are close to the surface and readily injured. Some growers cultivate thoroughly twice during the year, once in the spring and again in midsummer, and use the hoe as occasion requires to destroy weeds. Sometimes winter cultivation is practiced, especially in the south, where in parts of Los Angeles County strawberry fields are cultivated after every rain in the winter. Again there may be only one or two winter cultivations, and often they are confined to the late winter when the heaviest rains are over.

The type of cultivator used in many berry fields is an ordinary adjustable V-shaped spike-tooth one-horse harrow containing fourteen teeth. Some Pajaro Valley growers have a removable wooden drag, about 2 inches by 12 inches, which may be attached to the end of the cultivator to smooth the bottom of the furrow and spread the soil to the sides against the ridges, whence it has a tendency to wash down. Where the furrows are quite narrow, as in the single-row system, there is sometimes not enough space between the rows to permit the use of a horse-drawn cultivator and in such case it is necessary to do all stirring of the soil with a hoe or a hand cultivator. Sometimes the practice is to renew the furrows with a shovel-cultivator, or with an ordinary V-shaped cultivator with a broad shovel attached to the rear. In the Sebastopol district unirrigated strawberry fields are usually cultivated frequently throughout the season with a five-tooth V-shaped cultivator with tin shields along the sides to prevent the dirt from being thrown on the plants, for there they are not on raised beds.

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Hand cultivators are sometimes used also. Generally horse-drawn harrows are preferred in berry fields because of the deeper cultivation and greater amount of work possible in a given time.

In the case of bush fruits different cultural methods are followed, for the spreading foliage often serves to shade the furrows and reduce surface evaporation and consequent loss of moisture, at the same time making harrowing close to the ridges more difficult. Furthermore, owing to the wide spaces between the rows, it is possible to plow during the non-growing season, an impossible operation in the case of the closely planted strawberry beds. One of the objections to cultivation during the fruiting period cited with reference to strawberries, viz., the danger of bruising the berries, is made by many growers of cane fruits; but where the canes are trained to fairly high trellises and are kept from spreading too far it is found practicable to run a harrow through the furrows after irrigating, and in many sections this is done. Deep cultivation during the growing season, however, is avoided for fear of injuring the fine roots that closely approach the surface of the ground.

In Pajaro Valley some growers plow twice during the winter, once toward the vines and again away from them, forming the furrows, and harrow after each plowing, with no cultivation thereafter. Sometimes both plowings come in the spring. Some growers plow three times in winter and spring, and harrow afterwards. Others are found to cultivate after each irrigation, or to double the number of irrigations and to cultivate after every second one. In southern California the general practice is to cultivate all bush berries after each irrigation and several times in winter, though some growers dispense with summer cultivation, others cultivate after every second irrigation, and still others twice between irrigations. In Alameda County, currants, which are not irrigated, are usually plowed twice in the spring, and then harrowed every few weeks until picking time, with some hand work for eradication of weeds. Bush fruits in Sonoma County are often plowed three times in the late winter and early spring, then cultivated with a spike-tooth harrow or shovel-cultivator from four to eight times, usually only once after picking has started. Blackberries of the upright type, such as Lawtons, are tied to single posts and cultivated both ways, but the trailing Himalayas, Mammoths, and loganberries are necessarily cultivated in one direction only. For where not irrigated, as in the two counties last named, bush fruits are even more dependent than elsewhere upon proper cultivation for the retention in the soil of the preceding winter's rainfall and its availability for the maturing of the fruit.

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BOVINE TUBERCULOSIS

By C. M. HARING

In view of recent legislation in this state concerning the sale of dairy products, which becomes effective October 1, 1916, it has been deemed advisable to publish some fundamental facts concerning bovine tuberculosis. (See *California Statutes*, 1915, p. 1478.) This station has no responsibility concerning the new law. All communications concerning it should be addressed to the State Dairy Bureau or to the State Veterinarian. (See note bottom p. 2.)

Cattle are the most susceptible of all animals to tuberculosis. Hogs also contract the disease easily when fed on infected milk or when running in fields with tuberculous cattle. Poultry are sometimes affected with a form of tuberculosis, as are also household pets. In fact, there is no kind of animal that will not develop the disease, although horses and sheep are seldom infected. Tuberculosis is the most serious, infectious disease of man. The bovine type of bacillus rarely causes the lung form of the disease in adult human beings, but it is responsible for certain types of tuberculosis in infancy and childhood. The percentage of cases of the bovine type occurring among children depends on local conditions, and is variously estimated. The maximum found in any locality has been 25 per cent. The cause of this disease in children is infection transmitted through raw milk and cream. It may also be present in other dairy products, such as butter, fresh cheese, skimmed milk and buttermilk.

THE ECONOMIC ASPECT OF BOVINE TUBERCULOSIS

The losses due to the prevalence of this disease in farm animals are not as apparent as they are important. It is no uncommon thing for a veterinarian to find 70 or 80 per cent of the cows in a herd diseased without much loss being evident to the owner. Losses from deaths due to tuberculosis seldom become serious in a herd until the disease has spread to a majority of the animals. Often the first intimation that anything is wrong comes to the owner through the report

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from the abattoir that cattle from his ranch have been condemned as unfit for food on account of tuberculosis.

Reports of meat inspectors in San Francisco show that the number of tuberculous cattle coming from certain sections increased from nine-tenths of one per cent to nine per cent in five years. Recently the proportion of hogs condemned by meat inspectors on account of tuberculosis has increased markedly. This is an added indication of the spread of infection in cattle since the cow is the chief source of tuberculous infection in swine, the disease being transmitted to swine through milk or buttermilk from tuberculous cows, through infected cattle corrals or by feeding uncooked carcasses to the hogs. The enormous losses due to this disease are a tax upon every pint of milk and every pound of beef sold. That the aggregate loss to the state is enormous cannot be doubted, but, on the other hand, the loss to the individual owner is seldom so great as to make him ready to adopt measures involving a great deal of immediate trouble and expense, in order to secure eventual complete freedom from the disease.

WHAT ARE THE SYMPTOMS OF TUBERCULOSIS IN CATTLE?

There is no symptom that can be relied upon with certainty. A herd may be badly infected and yet none of the cattle show symptoms of ill health. Tuberculosis may attack almost any organ of the body, but until it has progressed to an advanced stage there may be no visible signs. Following are some of the more important symptoms suggestive of the disease, but it should be understood that these may also be caused by other diseases:

Unthriftiness.—In advanced stages of the disease the coat may become rough, the hair failing to shed readily with the change of

The new law gives this alternative: either to pasteurize the milk and cream sold at retail or to submit the cattle to an official tuberculin test. Dairymen who sell in bulk to the wholesale trade need not have their cows tested or install a pasteurizer. The responsibility of pasteurization rests on the creamery. In cities or counties having a dairy inspection service all milk retailed must be graded and properly labeled.

Every cow owner who intends to retail any unpasteurized milk or other dairy product, except cheese, should write to *The State Veterinarian, Sacramento, California,* requesting that his cows be tuberculin tested. Those intending to retail in any city or county having a dairy inspection service should file a duplicate request with the local health officer. After filing these requests the dairyman is not liable under the provisions of the law until the State Veterinarian or his representative shall be able to make the required tests.

Pasteurization on the dairy ranch will in most cases be impracticable. Any dairyman who is contemplating the installation of pasteurization equipment is advised to confer with the officials of the State Dairy Bureau or with the chief dairy inspector of the city in which his products are used, for many cities refuse to allow milk to be sold unless it has been pasteurized within the cites. It is, moreover, illegal to repasteurize milk to be sold for human consumption.

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seasons. The skin loses its suppleness and feels harsh and thick and is difficult to fold when grasped by the hands. This is especially noticeable in the neck or flanks. This condition is known as "hide-bound." The debilitated expression of the eyes and face, the bristling hair, arched back and tucked-up abdomen are symptoms which may or may not be present in advanced tuberculosis.

Loss of Flesh.—A gradual falling away should always be a cause for suspicion, but leanness is a common characteristic of good dairy cows; therefore a knowledge of the normal for each individual animal is necessary before judgment may be passed on this symptom. The owner or milker is often better qualified to decide these cases than a veterinarian who has never seen the animal before.

Cough.—This symptom is only present when the disease is attacking the lungs or some part of the breathing organs. It is usually rather subdued and infrequent and may occur only when the animal is driven or when she gets up after having lain down for some time. Tuberculous cows do not appear to cough up anything. This may be because they cannot spit. Most of the material coughed up from the lungs is swallowed, but many tuberculosis germs escape from the mouth in the spray.

Nasal Discharge.—A slight discharge of pus from the nostrils may occur in cattle with advanced tuberculosis of the lungs. This discharge is often concealed by the frequent licking of the nostrils and would be overlooked by any but a close observer.

Enlarged Glands.—Hard, painless swellings in cattle are apt to be due to tuberculosis. These are especially liable to occur in front of the shoulder, in the flank or groin, or in the region of the throat. Swellings under the jaw proper are more often due to actinomycosis or to the penetration of the tissues by foxtail beards. Tuberculous growths often develop in the throat or back of the jaws so as to produce a roughened sound in breathing.

Hard Lumps in the Udder.—When tuberculosis attacks the udder no change can be detected at first, but after a time hard lumps can be felt in some parts of the organ after it is milked out. Milk from such an udder must not be used.

Chronic Bloating.—Sometimes the diseased glands in the chest prevent the usual passage of gas from the paunch to the mouth by pressing on the gullet. The resulting bloat is recurrent or chronic and easily distinguishable from the acute bloating caused by green alfalfa.

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Diarrhoa.—Looseness of the bowels or "scouring" is seen in advanced stages, particularly when the disease is generalized. This kind of scouring does not yield to treatment.

WHAT TUBERCULOSIS IN CATTLE LOOKS LIKE

When the carcass of the cow affected with tuberculosis is opened, the disease may be found in any part of the body, but it is usually located in the lymph glands of the chest, throat, or abdomen. The exteriors of the tubercles often look like masses of pearls and on this account years ago the disease was called pearl disease of cattle. Tissues showing lesions of tuberculosis in cattle and hogs can be seen in the veterinary exhibits of the College of Agriculture at Berkeley

THE CAUSE OF TUBERCULOSIS IN CATTLE

Although there is much that is yet to be satisfactorily explained concerning the way in which cattle contract tuberculosis, it is definitely known that the disease results from the invasion of the tissues of the body by bacteria.[2] The bacilli of bovine tuberculosis are believed to exist only in the tissues of diseased animals and in their excretions, or on substances contaminated by these excretions. Except under the most favorable conditions they do not multiply outside the body, although if not killed by sunlight or disinfectants they may survive in dirt for several months.

[2] The *Bacillus tuberculosis* (Koch) belongs to that genus of microscopic plants known as discomyces or mycobacteria. When the infected tissue is smeared on a glass slide and properly stained the bacteria may be seen by means of a high-power microscope as slender, slightly bent rods, .00006 to .00015 inch in length by .00001 to .00002 inch in diameter. These organisms do not stain readily with ordinary aniline dyes. Once stained with carbol-fuchsin, however, the dye is retained even after the application of alcohol or 30 per cent sulphuric or hydrochloric acid. For this reason tubercle bacilli and a few other species of bacteria are classed as "acid and alcohol fast," as distinguished from those which lose the color of their stain when treated with alcohol and acid. Tubercle bacilli are not readily obtained in pure culture from tuberculous tissues. The usual method is to inoculate guineapigs and from their diseased tissues inoculate a large number of tubes containing egg media. When once started to grow on egg media the germs can be transferred and more readily cultivated on glycerine bouillon.

Tubercle bacilli of cattle, man and birds may be distinguished from one another by appropriate laboratory methods. A culture of bovine tubercle bacilli may be distinguished from the human type by the fact that it grows feebly and the acidity of the bouillon decreases, while the growth of the human type is luxurious and the media, although first reduced in acidity, become more and more acid with the age of the culture. The human and bovine types appear to be equally virulent for guineapigs. The human variety is not often fatal to rabbits or cattle and the tissue changes which it produces in these are very slight and restricted to the point of inoculation. The bovine variety when inoculated into cattle or rabbits is usually fatal.

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HOW THE DISEASE SPREADS

When an animal first becomes infected there is usually no danger to other cattle, but sooner or later tuberculous cattle begin to give off the germs of the disease. The germs escape through the mouth and nose, the bowels, the milk and with discharges from the genital organs. When the disease is located in the lungs and discharges into the air tubes, pieces of diseased tissue and millions of germs are liberated and coughed up. Most of these are swallowed and passed out in the manure. This is the chief way in which the germs are discharged from diseased cattle. When the germs are being given off in any of these ways, the disease is known as *open tuberculosis.* Cattle in advanced stages of the disease usually have open tuberculosis. The high percentage of tuberculous cattle and hogs on certain ranches has been found to be due to the failure of the owners to remove promptly animals that develop visible indications of the disease.

Germs discharged from the mouth and nose are coughed up from the lungs and are sprayed over the food in front of the cow or are carried in the air for a time until they fall to the ground. Cows in adjoining stalls may take in these germs in the air they breathe or in the food they eat, and so contract the disease.

Germs discharged from the bowels are mixed with the manure and may infect cattle and hogs that are allowed to pick over the dung heap. The practice of having hogs and cattle together in the same yard often results in the infection of the hogs, if any of the cattle are affected. Manure containing tuberculosis germs may easily infect the milk. Particles of dried manure may fall into the milk pail from the skin of a dirty cow or be accidentally flicked off from the tail and fall into the milk. Straining the milk afterwards only removes the larger particles. The smaller ones, including the germs, remain in the milk. When the udder is tuberculous, the milk contains the germs in vast numbers. Although such milk may look and taste perfectly good, it may transmit the disease to young animals. Hogs and calves are readily infected by it. It is also dangerous to children.

When all the tuberculous areas in the body are so situated that no germs are being given off or discharged in the secretions, as above described, the condition is known as *closed tuberculosis.* Such animals do not transmit the infection until they become so diseased that the tuberculous areas open into a passage leading to the exterior of the body. Many infected cattle never develop *open tuberculosis,* but there is no way of determining accurately in living cattle which are the open cases and which are closed. In badly infected herds a careful

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physical examination by a veterinarian will eliminate a certain proportion and a much larger proportion may be detected by the inoculation of guinea pigs. This latter procedure, however, is impracticable under average dairy conditions and it will fail to detect those cases which do not happen to discharge germs at the exact time the sample is taken.

Rate of Development.—Individual animals exhibit the widest variation in the duration of the disease. In the majority the disease pursues a leisurely course, consuming years before causing death. Most infected cattle are fattened and sold for beef, but some develop a rapidly fatal type. Its onset is always unobtrusive and its progress is so gradual that its presence does not cause apprehension. Losses are so evenly distributed in point of time that they do not excite serious alarm, as do other less destructive diseases of the pestilential type which kill many suddenly. The rate of spread in a herd is variable. In some herds which are known to have a few reacting animals the disease does not seem to spread. Perhaps this is due to the fact that few, if any, of these happen to be *open cases.* On the other hand, in certain instances under observation the disease has been introduced into clean herds and in a few months, through the development of open cases, a large proportion of the cattle have become *reactors.* The feeding of infected milk to calves, particularly unheated mixed skim-milk returned from the creamery, usually results in speedy infection.

HOW A HERD IS INFECTED

Tuberculosis may be introduced into a healthy herd in a number of ways:

1. By the purchase of a bull or other animal that is infected with the disease. This animal may be apparently healthy at the time of purchase, but if previously exposed the disease may develop and spread to other cattle. Where a healthy herd is being maintained, animals should only be bought subject to the tuberculin test and even this precaution may fail if the herd from which they come is badly infected.

2. By feeding calves with milk, buttermilk, or whey that has come from tuberculous cows. A farmer may have a healthy herd, but, if he brings home skim-milk from a creamery and feeds it to his calves, the disease, if present in the milk, may be transmitted to them. Such milk should be rendered safe by boiling or pasteurizing.

3. By showing cattle at fairs and exhibitions where proper care is not taken to keep out diseased stock, or to disinfect the stables.

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4. By shipping animals in cars that have not been disinfected, as these may have recently carried diseased cattle.

5. By allowing the cattle to graze with diseased ones, or to come into contact with them over fences.

6. When the cattle are permitted access to small ponds, water holes, or troughs, these may become badly contaminated with infected manure from "open cases." The rapid spread of the disease on certain ranges is believed to be due in part to infected water.

HOW THE PRESENCE OF TUBERCULOSIS INFECTION MAY BE DEMONSTRATED

The tuberculin reaction is the best method at present available for the recognition of tuberculous infection in cattle. There are several reasons why this special test is necessary. Unless cattle are very badly diseased they seldom show symptoms of ill health. Almost any organ of the body may be attacked, but until the abnormal process has progressed far enough to interfere seriously with some function no symptoms can be detected. The thickness of the skin and chest wall makes it difficult to detect a diseased condition in a cow's lung by listening to the sounds made in breathing, whereas this is comparatively easy in human beings. Next to the tuberculin test, a careful physical examination by a trained veterinarian is the most practicable method of diagnosis; in fact, the tuberculin test should always be supplemented by such an examination, since badly diseased cattle often do not react to the test.

Other methods which occasionally may be useful in detecting the disease are microscopic examination of diseased tissue, exudates from the pulmonary, intestinal or urinary tracts and pus from abscesses, or animal inoculation with such material. The latter is a much more certain test than a direct miscroscopic examination. Guineapigs are usually employed for this purpose.

What is Tuberculin and its Reaction? Tuberculin is the filtered, sterilized and preserved glycerine bouillon upon which tubercle bacilli have grown. It contains no germs and is harmless to cattle even in increased dosage. In tuberculous cattle it produces a temporary effect or reaction. The living tissues of tuberculous persons and animals are sensitive to tuberculin. This sensitiveness is most marked in the tissues that are actually invaded by the germs, but it also exists to some extent in the other tissues of the body which contain bloodvessels. The living tissues of individuals not infected with tuberculosis show no sensitiveness to tuberculin.

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When tuberculin is injected into the vascular layers of the skin of a tuberculous cow a swelling will usually follow. When dropped on the eyeball an exudate of pus may result. When injected into the skin or tissues in sufficient amount a feverish attack comes on about eight to twenty hours after the tuberculin is administered, lasts a few hours and then subsides. These symptoms are called *reactions* and animals which show them are called *reactors*. The value of the test lies in the fact that diseased animals react, while healthy ones do not.

There are several ways of testing with tuberculin. The methods which are most practicable are the *intradermal,* the *subcutaneous* and the *ophthalmic*. Each of these methods has certain advantages. The conditions under which the testing is to be performed should be the guide in choosing the method. The successive or combined use of all three tests on the same animals gives the highest accuracy in diagnosis.

THE INTRADERMAL METHOD

The tuberculin is injected into the deeper layers of the skin, or into the subdermal tissue immediately adjacent, in $\frac{1}{20}$ to $\frac{1}{4}$ c.c. amounts, depending on the concentration of the tuberculin used. A hypodermic syringe with a short needle-point should be used. Such a syringe should have a 25 or 26 gauge needle with a point three-sixteenths to one-quarter of an inch in length, similar to those used by dentists for injecting local anesthetics. The most suitable place to make this injection is one of the folds of the skin on the under side of the base of the tail.

Standing against the right flank of the cow, the left subcaudal fold is grasped between the thumb and the first two fingers of the left hand and the needle inserted into that portion of the skin held between the thumb and finger. The dose, if properly placed, can be felt as it is expelled from the syringe in the layers of the skin, where it remains as a small lump in the skin after the needle has been removed. The mistake of trying to inject as near the surface of the skin as possible should be avoided. It is difficult to inject into the layers of the epidermis and an injection into this part of the skin is of little diagnostic value. In case the needle is of the proper length, namely, one-quarter of an inch, there is little danger of going completely through the skin. When the proper point in the subcaudal fold is selected, it makes little difference whether the point of the needle is in the dermal or in the subdermal connective tissue. It is well to inject at a point on the fold about two and one-half or three inches down the tail from the anus, since elsewhere reactions are not so easily perceived, and at this point the bone and solid tissue of the tail form a background which renders the local reactions prominent.

The skin of the lower eyelid has been used in some of the tests at this station, but the subcaudal fold has been found to be more satisfactory. This method of injecting the tuberculin intradermally into the lower eyelid is called the intrapalpebral test and has been advocated by certain veterinarians as a cleaner and more convenient way to administer the test. It is, however, less practicable on account of the additional help needed. The reactions are at

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times difficult to distinguish from the normal fullness of the lower eyelid, and on this account it is necessary to examine and compare the tissues beneath both eyes in deciding a reaction. It is a difficult method to use on range cattle.

The Reaction to the Intradermal Injection in Cattle. A positive intradermal reaction is indicated by a thickening of the subcaudal fold or by the appearance at the point of injection of a characteristic sensitive swelling varying in size from that of a pea to that of an orange. The swelling may be either soft and oedematous or hard and inflamed. The majority of reactions are seldom clear before the twelfth hour and when testing in infected herds new reactors continue to appear until the seventieth hour. In some instances we have observed that the early local reactions disappear before the forty-eighth hour, while in several cases we noted reactions which did not appear until the ninetieth hour. In order to be certain of every case, observations must be taken at least twice, preferably about the thirty-sixth and seventy-second hours. If only one observation can be made, it should be on the seventy-second hour. *Small indurations at the point of inoculation about the size of the head of a parlor match frequently occur in normal non-reacting cattle, but any larger than this which persist to the seventy-second hour should be considered a positive reaction.*

In judging a local swelling, the observer should depend more upon the shape, appearance, tenseness, sensitiveness and location with respect to the exact point of injection than upon actual measurements. Only experience can teach an operator how to be certain of a positive reaction when the local swelling is small. This is especially true when tuberculin containing glycerine has been used. Usually tuberculous cattle also show a temperature reaction to the intradermal injection.

THE OPHTHALMIC METHOD

An assistant should grasp the animal by the nose and turn the head at an angle so that the operator may drop one or two drops of the tuberculin directly upon the eyeball. A small hypodermic syringe with the needleshank broken or filed off is more suitable for this purpose than a medicine dropper. The eye is then closed for a few seconds by pressure from the palm of the hand. A preliminary instillation to render the eye sensitive should first be given as just described, but it is not necessary to take observations concerning the results of this. The second or test instillation is made in the same eye in from three to fourteen days. The reaction in tuberculous cattle usually sets in by the eighth hour. In cattle whose eyes have been sensitized by a previous instillation it may set in by the third hour. It manifests itself by a purulent exudate which accumulates at the inner corner of the eye and usually runs down the face. This sometimes dries up and drops off in a few minutes, so that the evidence of the reaction may quickly and entirely disappear, although occasionally pus discharge can be seen for several days. Although the results of the test are usually apparent by the twelfth hour, they may occur as early as the third hour, and observations should be made as frequently as practicable from the third to the twenty-fourth hour. The test is only satisfactory when cattle can be kept tied or confined in stanchions under shelter for a period of at least 16 hours, except in the case of cattle which show a reaction before that time. It is advisable not to feed unchopped hay on account of the possibility of wiping off the exudate.

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THE SUBCUTANEOUS METHOD

This method consists in injecting one to four cubic centimeters of tuberculin beneath the skin of the neck or shoulders. The reactions consist of a feverish attack, characterized by a rise in temperature and occasionally by symptoms of depression, shivering, bristling hair, ceased rumination and looseness of the bowels. In some cases these symptoms are noticeable, while in others they do not appear at all. The temperature rise after the injection of tuberculin in a tuberculous animal, however, is seldom absent and usually occurs between the eighth and the twentieth hours. The normal temperature of a cow varies between 100° F. and 103° F. Calves and fat stock may range to 103.5° F. During the tuberculin reaction the temperature rises to a height varying between 103° F. and 108° F. The positive tuberculin reaction generally shows a regular rise, the temperature remaining at the highest point for a short time, then falling gradually to normal. The highest point is usually between 104° F. and 107° F., but in some reactors may be as low as 103.2° F. and in others reach 108° F. It is not always an easy matter to distinguish between some reactions and the variations in temperature in the normal healthy animals. The temperature of cattle is quite erratic, being influenced by the weather or any change in the usual routine of handling. During the severe north winds which sometimes occur in central California the temperature of herds of normal cattle may average over 103.5° F.

Directions for Taking Temperatures. Continue the normal temperatures until they drop below 103° F. Take subsequent temperatures every two hours between the eighth and twentieth hour. If any subsequent temperature reaches 103° F., take another temperature in one hour. If at the twentieth hour after injection any animal shows a rise in temperature above previous temperatures for the day continue taking the temperature as long as the rise is continued.

WHEN THE VARIOUS METHODS SHOULD BE USED

The intradermal method is the form of the test which will be used in most cases by the State Veterinarian in enforcing the new dairy law. Since the reaction to tuberculin when injected intradermally depends upon a swelling at the point of injection and not on a rise of temperature, it is to be preferred to the subcutaneous method under all conditions which are liable to modify the tuberculin temperature curve. It can be satisfactorily applied to calves and wild range cattle and is especially useful in testing cattle during the hot season in the interior valleys of this state under conditions rendering both the subcutaneous and ophthalmic methods of testing unsatisfactory. It excels these methods in economy of time, labor and materials.

The ophthalmic method is desirable where favorable arrangements can be made for housing the cattle during the test and when there is time to repeat the test. The chief advantages are: (1) It does not render the cattle insensitive to subsequent tests by other methods. (2)

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It will cause reactions in tuberculous cattle that have been "plugged," i.e., treated with tuberculin to render them insensitive to a test. (3) The technique of the test is simple and the interpretation of the reactions requires less skill and experience than the intradermal reactions. (4) In case of doubtful reactions, the test may be repeatedly administered to the same animal.

The subcutaneous method is the original way of testing and is the only method officially accepted in all states and by the United States Department of Agriculture. On account of its extensive use for many years its possibilities and limitations are understood by nearly all veterinarians and by many stock owners. Its proper application requires less practice and the results can be more readily interpreted by the inexperienced. The record of the reactions can be graphically expressed in the form of a temperature curve. The use of this method is especially to be commended in infected herds as an additional precaution to be applied following the use of the other two tests.

LIMITATIONS OF THE VARIOUS METHODS OF TESTING

No form of the tuberculin test distinguishes between severe and slight cases, nor between those that are spreading infection and those that are not inconvenienced by the disease and are not infecting others. The test is so searching that extremely slight infection will cause the animal to react. In cattle reacting to the test the infection may occasionally be so recent and the changes so slight that the ordinary methods of post-mortem examination fail to demonstrate the presence of tuberculosis, since the lesions may be microscopic in size. If a reaction *does* occur, tuberculosis is certainly present, although it may be very slight; but if no reaction occurs care must be taken, for there is still a possibility that the disease is present. Following are some of the factors to be considered:

(1) The animal *may* not react if very extensively tuberculous, but in such cases physical symptoms will usually indicate ill health.

(2) The reaction does not occur during the period of incubation of the disease; in infected herds a second test should, therefore, be made within six months.

(3) Cows that have once reacted may fail to do so upon subsequent tests, the lesions being encapsulated or arrested, but frequently in such cases the disease is known to have become active again after a time.

(4) The possibility of the cattle having been "plugged" by the previous injection of tuberculin must sometimes be taken into account.

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The discovery that the ophthalmic test will usually cause reactions in "plugged" tuberculous cattle has somewhat decreased the importance of the chance of error. Dr. James Law in his treatise on veterinary medicine gives seventeen conditions under which he believes the subcutaneous method to be unreliable. In most instances these do not apply to the intradermal or ophthalmic methods. Only those who have been especially trained and, in addition, have had considerable field experience can secure accurate results in testing badly infected herds. Each form of the test has its special value and limitations. Nevertheless, the tuberculin test must be looked upon as the most accurate and valuable means at hand to assist in the diagnosis of tuberculosis.

(5) Frequently tuberculous animals have been observed to react to one form of test and fail to respond to the others. This peculiarity in some infected animals has not been satisfactorily explained, although the proportion of such animals is sufficient to be of considerable practical importance. A large proportion of such cases may be due to lack of sufficient care to observe the effects of the tuberculin upon the individual, i.e., failure in the subcutaneous test to take sufficient temperatures; failure in the intradermal test to inspect the point of injection at proper intervals; failure in the ophthalmic test to keep the animals under proper environment and constant observation.

THE COMBINED OR FOLLOW-UP SYSTEM OF TUBERCULIN TESTING

In badly infected herds the maximum efficiency by the ordinary technique used by veterinarians in routine work probably averages less than 90 per cent for any one method of tuberculin testing, the errors being due chiefly to failures to secure or detect reactions in the tuberculous cattle. Before accrediting a previously infected herd as free from tuberculosis, the veterinarian should use the combined methods. The following procedure, which we have called *the follow-up system,* is advised:

(1) Apply the ophthalmic test two times at intervals of about one week, the results of the second test being watched with great care.

(2) Follow this by the intradermal test, using $\frac{1}{5}$ c.c. of a strong tuberculin solution, such as 10 per cent precipitated tuberculin, and take temperatures as in the subcutaneous test above described. Examine the point of injection for local reaction at about the 36th and 72nd hours. In case the herd is to be retested by the subcutaneous method, the taking of temperatures may be omitted and the intradermal dose reduced to $\frac{1}{10}$ c.c. of ordinary veterinary or 5 per cent precipitated tuberculin.

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(3) After a lapse of at least six weeks,[3] the subcutaneous method may be applied to all animals that have not been removed by the previous tests. The additional precaution of occasional ophthalmic tests is sometimes also desirable.

(4) All herds having reactors should be retested every six months and herds free from reactors annually.

This station has found the above system desirable in building up a clean herd where the only supply of animals was from very badly infected herds. For a number of years the alternate use of the intradermal and subcutaneous methods semi-annually has been in vogue in most certified dairies in this state, and whenever an unusually large percentage of reactors has been found the *follow-up system* has been used.

DISPOSING OF REACTING CATTLE

Slaughter for beef under inspection is the recommended method of disposal of all reacting cattle which show no visible signs of the disease, except in those cases where the beef value would be very much less than the dairy or breeding value. The method formerly and most commonly employed of disposing of reacting animals was by slaughter and burial. Where this wasteful method has been employed the results have been discouraging; even when the state recompensed the owner in part for the loss of his stock, it has been unsatisfactory. A large number of reacting animals are usually but slightly diseased. They readily take on flesh and can be fattened and used for beef. The university practices what it preaches in this regard. They must be carefully examined by a veterinarian when killed and if the disease is found to be extensive the carcass must be condemned. The federal government meat inspection regulations admit the use of meat for food from animals that show limited lesions of tuberculosis, for it is recognized that such meat does not contain tubercle bacilli and, besides, the common procedure of cooking meat is a further safeguard against danger. The zeal of various health officials in demanding the waste of the flesh of every reacting animal has been a great drawback to the control of tuberculosis through developing opposition.

THE CONTROL OF TUBERCULOSIS

In the application of any methods for the eradication or prevention of tuberculosis certain important characteristics of the disease should be borne in mind:

[3] The intradermal test appears to have some modifying effect on a subsequent test by either the intradermal or subcutaneous methods, but this is not so pronounced as that produced by the subcutaneous injection and retests may safely be made in six weeks.

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(1) *Its indigenous nature.* Bovine tuberculosis is so firmly rooted and so widespread among dairy cattle that no important dairy community, the Island of Jersey excepted, is free from it. So far as is known, no dairy section when once infected has been able to eradicate the disease completely. The possibility of eradicating bovine tuberculosis from individual herds has been demonstrated beyond all question, and the obstacles which have prevented the successful accomplishment of this in communities, states, or countries have been due to the unwillingness of the cattle owners to make the necessary financial sacrifices.

(2) *Its specific nature.* Tuberculosis does not develop spontaneously. The cause of the disease is the bacillus of tuberculosis, which exists only in the bodies of tuberculous animals and in their secretions, or in substances contaminated by them. In-and-in breeding cannot produce it. Dark, filthy, badly ventilated stables, poor food and crowded conditions may contribute to its rapid spread among cattle, but the disease does not originate in an animal, no matter how bad its environment. It must be exposed to the disease germs to contract the disease.

(3) *Its infectious nature.* Tuberculosis is most readily communicable. This point, in connection with its specific nature, cannot be too strongly emphasized. The disease results from the association of tuberculous cattle with healthy ones and under such conditions will spread in spite of every sanitary precaution. It is a mistake to assume that the disease cannot thrive and multiply among dairy cattle kept under ideal conditions. The invigorating influence of fresh air and sunshine, wide, well watered pastures, well ventilated, ideally constructed, immaculately clean barns, and abundant and well balanced rations will not stop, although they are likely to retard the spread of the disease. It is among some of the best kept herds that the disease has been found to be alarmingly prevalent. Contact, direct or indirect, is the chief way in which the disease is disseminated. Calves most frequently contract the disease from the milk. Calves and hogs fed on pasteurized milk from tuberculous cows soon become infected.

STATE MEASURES TO CONTROL BOVINE TUBERCULOSIS

The responsibility for the spread of bovine tuberculosis rests with the owners of infected cattle, but it is the duty of the state, from economic as well as public health reasons, to aid them in the difficult task of controlling the increase of this disease in live stock. In this state, up to the present time, practically nothing has been done and

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the law soon to be in force is intended purely as a public health measure.

Unfortunately, but unavoidably, the early efforts to eradicate bovine tuberculosis were undertaken without a full appreciation of the magnitude of the problem. In some states having compulsory tuberculin test laws the scheme of indemnification by the state was introduced. With funds that it has been possible to get from legislatures the work has made no progress and with few exceptions tuberculosis has kept pace with the puny efforts directed against it. The attempts by states to eradicate the disease in cattle by tuberculin testing and the slaughter of all reacting animals have proved impracticable.

SUPPRESSION OF THE DISEASE BY THE COW OWNERS

The first step in getting rid of the disease is to find out how many of the herd are affected. This is done by applying the combined tuberculin tests with careful physical examinations. The proper course to pursue will depend largely upon the proportion of reactors found. Suppose a few cattle react, say less than 15 per cent. Individual owners of such herds are advised to start to exterminate the disease immediately. The steps necessary are:

1. Isolate all the reactors, including cattle which may have given doubtful or questionable reactions. Non-reactors which on physical examination show any symptoms attributable to tuberculosis must be included. It is unquestionably a good policy in herds showing such a low percentage of infection to sell the reacting cattle for beef, or to establish a separate infected herd, the milk of which is pasteurized.

2. Thoroughly clean and disinfect premises.[4] Since chemical disinfectants in dilutions practicable for the liberal use required in disinfecting stables and corrals act very slowly in killing tubercle bacilli, most dependence should be placed on thorough cleaning, painting and whitewashing. Particular attention should be given to the absolute removal of all manure, the smallest particles of which may harbor innumerable tuberculosis germs.

3. Retest the herd in two or three months by applying the ophthalmic method at least twice and immediately remove all reactors and again clean and disinfect. Every six months apply either the intradermal or subcutaneous test. In such semi-annual testing we prefer to alternate the subcutaneous and intradermal methods.

[4] Literature describing the methods of stable disinfection may be obtained free from the College of Agriculture, University of California, Berkeley, California.

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4. Additions to the herd should be subjected to the tuberculin test and, in addition, should come from herds that are comparatively free from reactors. The purchase of cattle from badly infected herds, even when they pass the tuberculin test, is unsatisfactory. When purchasing cattle it is usually impossible to find any for sale from herds known to be free from tuberculosis, but in several dairies under the supervision of this station it has been found entirely practicable to follow the rule of purchasing only from herds having less than 10 per cent of reactors. Since the adoption of this 10 per cent rule the proportion of reactors at each semi-annual test has been much less. Owners of herds that are comparatively free from tuberculosis should make few purchases, but depend on the raising of the calves. *There is great danger in buying non-reacting cattle from infected herds—that is, animals that have been exposed to infection. The unit to deal with in buying cattle is the sound herd rather than the non-reacting individual animal.*

In the dairies near cities, where it is not economical to raise the calves and the milking herd is kept up by the constant purchase of "springers," or fresh cows, it will be impossible to keep the herd free from reactors, although in certain dairies of this class the number of reactors is kept down to an average of about 3 per cent by semi-annual testing and the prompt removal of reactors.

The Suppression of Tuberculosis in Moderately Infected Herds. In herds having from 15 to 50 per cent of reactors the best course to pursue is not as definitely known as in badly infected herds, where it is hopeless to try to separate the infected from the healthy and where dependence must be placed entirely in the raising of healthy young stock; or in slightly infected herds, where it is always advisable to stamp out the disease by repeated tuberculin tests and the prompt removal of all reactors. In moderately infected herds there are many healthy cattle which can be saved from infection and it is undesirable to leave them with the infected herd, while, on the other hand, the economic sacrifice entailed in the sale of all reacting cattle often would be a far greater loss than any that would be caused by the disease itself.

The so-called *Bang System* is sometimes advisable. The method is as follows:

1. Test every animal in the herd with tuberculin.

2. Remove the reacting animals and keep them isolated so that the disease cannot be transmitted to the healthy animals either by contact, by the attendants, or by the same feeding or drinking utensils.

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3. Clean, disinfect and paint or whitewash the stable to prevent transmission of the germs left by the infected animals.

4. Test the healthy herd with tuberculin regularly to detect any cases that may develop and remove such animals before they spread the disease. Disinfect again.

5. Remove the calves from the diseased herd at birth and feed them milk from the healthy cows or milk from the diseased cows after thorough pasteurization by heating to 160 ° F. for 20 minutes.

As the sound herd is replenished, the isolated cattle may, if desired, be fattened and killed for beef under proper inspection. When new or non-infected buildings and corrals and well separated pastures are available for housing the non-reacting cattle this *Bang System* or some of its modifications may be attempted. Through the failure to guard against the limitations of the tuberculin test by repeated retesting, or through inadequate separation of the two herds, many, after trying this system for years, have failed to make headway in building up a healthy herd. In many instances it will be cheaper for dairymen in whose herds over 35 per cent of the animals react to keep the entire adult herd as one unit and for a time devote all efforts to protecting the new-born calves. In such cases a frequent physical examination of the infected herd is desirable in order to eliminate clinical cases as soon as possible after they develop.

In herds having less than 35 per cent reactors it may sometimes be desirable to try to stamp out the disease by repeated tuberculin testing and the prompt removal of all reactors, each test being followed by a thorough cleaning and disinfecting of the premises. The tuberculin tests must be interpreted very rigidly and all questionable reactions treated as if they were positive; otherwise the procedure will often fail to stop the headway of the disease until so many animals have been changed by repeated tests and additions that the majority of the animals have been substituted.

In badly infected herds one should proceed as if every animal were infected. In herds having over 50 per cent of reactors all of the mature cattle should be treated as if infected. The tuberculin test is of value in indicating that a severe infection exists, but not of value in such herds as a means of dividing the non-infected from the tuberculous. To control the disease dependence must be placed upon the following procedure:

1. Eliminate promptly all animals developing physical signs of the disease.

2. Remove all calves at birth and raise them on boiled or pasteurized milk.

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3. Keep all healthy young stock isolated from the infected herd, infected fields and water. Test them every six months by the intradermal method and remove any reactors.[5]

Calves are so seldom born tuberculous that such means of transmission may be ignored; hence, if all calves were kept free from the disease it would require only one generation of cattle to eradicate tuberculosis. In carrying this principle into effect the ideal way would be to build up a separate herd from the healthy young stock. This, however, is not always practicable. When it is necessary to add the healthy young stock to the infected herd all of the cattle should be given careful and frequent physical examinations by a veterinarian to eliminate the open cases as far as possible. This procedure of protecting the calves and young stock and of keeping down the proportion of open cases by frequent physical examinations is called *Ostertag's System,* named after its chief advocate, Dr. Robert Ostertag of Berlin, Germany. This system is a process of gradually weeding out and reducing the disease rather than a process of complete eradication.

THE IMPORTANCE OF SEGREGATION AND ISOLATION

In large herds it is advisable to keep the cattle in small units. In constructing buildings and corrals, plan at the least to have separate corrals for each group of fifty or sixty cattle. Provide separate water troughs for each corral. Train the cows to stand always in the same stanchion. Do not feed the calves with the sweepings from the feed troughs in the dairy barn and do not permit hogs or goats in the cattle corrals.

SUGGESTIONS REGARDING SANITATION

Construct water troughs so that the drinking water of the cattle does not become contaminated with manure. Do not allow the cattle access to ponds or water holes. Have plenty of windows to admit an abundance of sunlight to all buildings. Direct sunlight is more deadly to fully exposed tubercle bacilli than carbolic acid, cresol, corrosive sublimate or chloride of lime in the dilutions generally used in disinfecting.

One would suppose that tight barns would be unnecessary in California, where the cows can live out of doors for a greater length of time than in the eastern states, but it must be admitted that the climate

[5] Even when the non-reacting cattle are at once removed from a herd having over 50 per cent reactors they should be looked upon as suspicious until some time has elapsed and they have successfully passed repeated tuberculin tests. The repeated use of the ophthalmic test is useful in such cases.

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of the coast counties requires warm shelter for high-grade dairy cows. Ventilation is a sanitary factor which in some instances has been neglected. This should be provided not only in milking stables but also in the barns used exclusively for shelter and feeding.

HOW CLEANLINESS HELPS

The desirability of cleanliness in milking, cooling and transporting milk is realized by all. Few, however, realize the significance of cleanliness as a factor influencing the health of the cattle. Since the manure of tuberculous cattle often contains living tubercle bacilli in vast numbers, the importance of keeping it well cleaned out of the stable and corrals is readily seen.

Stables should be cleaned out regularly and the manure put where it cannot be picked over by hogs or cattle. These animals are easily infected in that way. Cleanliness also includes keeping the walls and ceilings free from dirt, dust and cobwebs. These are all good resting places for disease germs.

Whitewashing the interior of the stable at least twice a year is a great aid to cleanliness and also has a distinct effect in destroying disease germs, especially when applied after thorough cleaning. In many municipalities dairy stables are required to be whitewashed at regular intervals. This should be a universal practice.

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HOW TO OPERATE AN INCUBATOR

BY J. E. DOUGHERTY

Getting Ready.—Before the beginning of the hatching season each year, the incubator equipment should be carefully gone over. Each incubator should be overhauled to see that all mechanical parts are in good order and working freely. One or two extra thermometers and a few wicks should always be kept on hand.

Locating the Incubator.—Place the machine in a room where the temperature remains fairly uniform at all times and where there is plenty of ventilation without drafts. A cellar is usually best because it is well protected from the direct rays of the sun and the temperature is uniformly low. A good temperature for an incubator room is 60 degrees F. In this climate good ventilation is easily secured by removing the windows wholly or in part and inserting in their places frames covered with light muslin. The air will pass through the muslin but the wind will be shut out.

Having located the incubator, level it with a spirit level. Leveling is very important, for if the machine is not level, one part of the egg tray will be higher than another, and the eggs in that part will therefore obtain more heat than the others.

Disinfection.—Before and after every hatch, the incubator should be thoroughly washed and sprayed and the movable parts placed in the sun to dry. Thoroughly cleanse every part with soap, water and a good scrubbing brush. A few hours before putting in the eggs spray all parts of the interior of the incubator with a spray pump, using about a 2 per cent solution of some good disinfectant, such as cresol compound or any of the "eum" preparations. The fumes of the disinfectant will penetrate every crack in the hot interior of the egg chamber and the vapors remaining when the eggs are put in will, to some extent, disinfect the exterior of the eggs. To disinfect *thoroughly* the surfaces of the eggs, dip them fairly rapidly in 95 per cent pure alcohol just before putting them into the incubator. This

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is an advisable precautionary measure because certain very contagious diseases are believed to be transmitted from adult stock to newly hatched chicks by means of infection of the surface of the shell. *Coccidiosus* is one of these diseases.

The Lamp.—The lamp should be thoroughly cleaned, the burner boiled in a solution of washing soda and a new wick put in, if necessary, before the machine is started every season.

In beginning the hatch, use a medium flame, and adjust the thermostat to it. If too small a flame is used to start with, the flame cannot

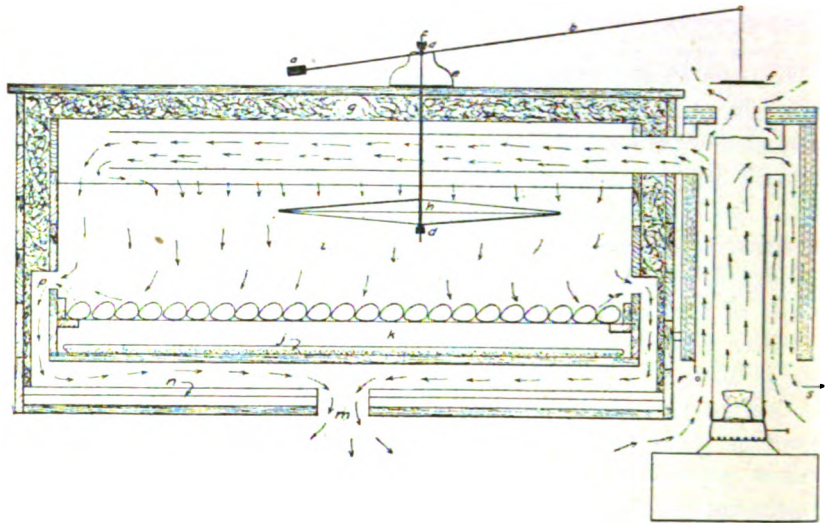

Fig. 1.—Cross-section of a hot-air heated incubator showing the method of regulating the temperature, the ventilation system, and the general construction. (*a*) Counterpoise weight; (*b*) regulator arm; (*c*) connecting rod; (*d*) thumb nut; (*e*) pivot casting; (*f*) heater disc; (*g*) cotton batting filling between inside and outside cases; (*h*) thermostat; (*i*) egg chamber; (*j*) moisture pan filled with sand kept wet; (*k*) nursery; (*m*) bottom ventilator for escape of air from egg chamber; (*n*) insulation in bottom of incubator; (*p*) one of four pipes to discharge air from above level of eggs into false bottom beneath egg chamber; (*r*) fresh air intake; (*s*) outlet for escape of lamp fumes. No fumes can get into machine.

be turned low enough at the end of the hatch, in warm weather, to keep the temperature from running up. If too high a flame is used the lamp will smoke.

The lamp should be cleaned and filled every morning *after* turning the eggs. If filled *before* turning the eggs, the hands, being smeared with oil from the lamp, will leave a coating of oil on the eggs and cause serious injury to the growing embryos. Trim the wick with a burnt match or cloth by simply rubbing off the charred crust and then wipe away all dirt and oil from all parts of the lamp

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before replacing in the incubator. In trimming, cover the end of the finger with a cloth and turn the wick just high enough to expose the charred part above the top edge of wick tube. Rub off the charred crust by rubbing in one direction only; this causes all the threads of the wick to lie smoothly in one direction and results in a more even flame. Then turn the wick up about one-sixteenth of an inch and pat down the corners lightly to prevent high corners on the flame, which would cause smoking. A flame that is straight across the top and rounded at the corners gives the most heat and will not smoke.

Thermometer.—In order to be certain that the thermometer is correct, the operator should test it himself with a clinical thermometer. Place both thermometers in luke-warm water and while stirring, add hot water slowly until the clinical thermometer registers 103 degrees. Observe whether the incubator thermometer gives a similar reading. If not, the operator knows that at 103 degrees the incubator thermometer reads, perhaps, 102½ degrees, and he must allow for this error in running his incubator. Faulty thermometers have caused more damage in the way of poor hatches than is generally realized.

Temperature.—In all incubators the temperature is regulated or controlled by a thermostat. The all-metal thermostat (see Fig. 2) consists of three pieces of metal riveted together at the ends and is designed on the principle that different metals expand different definite amounts for every degree F. rise in temperature and contract the same amounts for every degree F. fall in temperature. The central piece of metal (*h*, Fig. 2) does not expand or contract as much for every degree of change in temperature as do the two outside pieces. As a result, since all three pieces are riveted at the ends, the two outside pieces, expanding more rapidly than the central piece, are forced outward in the middle when the temperature rises. This buckling or spreading apart of the two outside pieces of metal in the thermostat causes a downward pull on the connecting rod (*c*), which in turn pulls on the lever arm (*b*) and raises the disc (*f*) off the heater.

When the temperature in the incubator rises *above* the desired temperature, the expansion of the thermostat lifts the disc from one-half inch to one and one-half inches above the heater, *allowing the surplus heat to escape.* But just as soon as the temperature returns to its proper place, the disc lowers again. If the temperature of the machine should drop *below* the "running" temperature, the thermostat will contract and allow the disc to settle down on the heater, thus *tightly closing the opening and forcing all the heat into the egg chamber.* When the temperature is properly regulated, the disc should

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stand about one-sixteenth to one-eighth inch above the opening in the top of the heater. There are a number of different kinds of thermostats or heat-regulating devices used on different makes of machines, but they are all based on the principle of expansion and contraction of a thermostatic device within the egg chamber to control the amount of heat entering, and thus automatically regulating the temperature of the egg chamber.

In the type of heater shown in Fig. 2, the *fumes from the lamp cannot get into the egg chamber,* but must escape through the opening (*s*). The fresh air (as shown by arrows) is heated by the lamp as it is drawn into the opening (*r*). It passes into the top of the incubator and then diffuses through a burlap or muslin diaphragm into the egg chamber. After circulating around the eggs, absorbing the carbon dioxide thrown off by the eggs and giving up oxygen, the air current passes through the openings at the sides of the egg chamber and escapes through the bottom of the machine.

The temperature throughout the hatch should be 102 degrees when the center of the thermometer bulb is on a level with the tops of the eggs. Hanging thermometers having the center of the thermometer bulb above the tops of the eggs need to be run higher according to the height of bulb above egg, because the heat in nearly all incubators comes into the egg chamber from the top and the nearer the thermometer is to the top of the egg chamber the higher it will read, when a standing thermometer on a level with the tops of the eggs registers 102 degrees F. While chicks are hatching the temperature can, and often does, run up to 104 degrees without doing any harm.

Ventilation.—Good ventilation of the egg chamber is a very important part of the process of incubation. During the growth of the embryo, it has for its food supply the stored-up food within the egg. In order to utilize this stored-up food and transform it into new body tissue, heat, and muscular action (such as the pumping of the blood through the blood vessels that radiate through all parts of the developing eggs), oxygen is absolutely necessary. Without oxygen, growth could not go on and the embryo would die. The net-work of blood vessels which extend in great numbers close to the underside of the shell and to the air-cell, take up oxygen from the incoming fresh air and throw off carbon dioxide, which has been given off as a waste product by the growing body tissues. Therefore, plenty of fresh air is essential to the production of strong, vigorous chicks. Briefly stated, the developing embryo breathes in fresh air through the pores of the shell and from the air cell. It exhales poisonous carbon dioxide

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through the pores of the shell and into the air cell. The ventilation of the incubator should be such as to carry fresh air into the egg chamber as rapidly as it is needed and to carry away the carbon dioxide as rapidly as it is given off by the eggs. *Insufficient ventilation will rob the chicks of vitality even though it may not prevent hatching.*

Insufficient ventilation in the egg chamber which is not always readily detected during the first nineteen days of the hatch will reveal itself after a good many of the chicks have hatched out. The panting of the chicks after hatching is invariably caused by too little ventilation, rather than by too much heat. Even though the hatch is not over, more ventilation must be given if the chicks already hatched are not to be weakened.

Moisture.—The process of exhaling in the developing egg is closely analogous to that in human beings. The exhaled air is laden with moisture, and it is as a result of giving off used moisture in this way that the eggs "dry down" during embryonic growth. This drying down causes a gradual loss of the water content of the egg and a correspondingly gradual increase in the size of the air cell. When the air passing through the egg chamber is very dry it not only takes up and carries off the moisture naturally exhaled by the egg, but also passes through the porous shell and absorbs still more moisture. It is because of this excessive drying down of the egg that the embryo is injured. Nature supplies the egg with just enough water to enable it to carry on its life processes and to evaporate gradually by the process of exhalation. From this we can clearly understand the vital necessity of having the air passing through the egg chamber sufficiently saturated with moisture to prevent undue evaporation of the moisture from the egg. Sixty per cent humidity is generally considered adequate.

It is evident that ventilation and moisture conditions are closely related and cannot be considered as separate problems. They must be handled together. Geographical location, time of year, and other factors will have to determine whether artificial means of adding moisture to the air entering the egg chamber is necessary or not. In the better types of incubators, ventilation is very well taken care of, so that the chief problem to consider is the maintenance of sufficient moisture in the circulating air. Always follow the instructions sent out by the incubator manufacturer in this regard until sufficient experience has been gained to enable one to act intelligently in making any change that may appear advisable. The increase in size of the air-cell,

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the drying of the membrane exposed when the chick pips the shell, the collection of moisture on the inside of the glass of the incubator door (see following page), and the ease with which the chicks break from the shell, together with experience, will serve as definite guides in properly regulating moisture conditions and ventilation in artificial hatching.

During the hatching period, frequent observations of the air-cells will indicate the rate of evaporation of the egg and if too much or too little moisture is being supplied. Experience will soon teach one the proper rate of evaporation as shown by a gradual increase in the

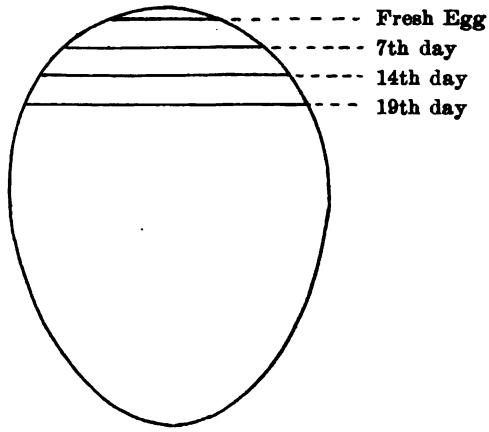

Fig 2.—Showing gradual increase in size of air-cell due to evaporation of water during the period of incubation.

size of the air-cell. A good plan for the beginner is for him to set a hen on the ground in an out-door setting coop at the same time that he sets the incubator and compare the increase in size of the air-cells in both cases every few days.

After the chicks have begun to hatch, *a light film of moisture* or *a few beads of water* should appear along the lower inside edge of the glass of the incubator door. Only a little moisture should collect on the inside of glass door. Too much humidity in the egg chamber is indicated at this time by too great a collection of moisture on the glass and can be corrected by increasing the ventilation or by reducing the moisture supplied. Too little humidity is indicated by no moisture on the inside of the glass door, and by the rapid drying and whitening of the shell membrane exposed around the edges of the opening where the chick has pipped the shell and before it has gotten out. As

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this shell membrane dries it becomes tough, and the chick is unable to tear through it and dies in its efforts to get out. The membrane should remain moist while the chick is breaking out of the shell, for it is then soft and easily torn.

One of the best ways to supply needed moisture when using a "non-moisture" machine, is to keep the floor well soaked. The evaporation of moisture is in proportion to the water surface exposed to the air, so that wetting down the floor exposes a large water surface and enables the air to become well saturated before entering the incubator. The purpose of such moisture is not to supply it to the eggs, but to keep the air entering the incubator moist enough not to take up too much moisture from them and thus rob the embryos of the water they absolutely need in order to develop into strong, lusty chicks.

Turning.—Turning is usually begun twenty-four to forty-eight hours after the eggs are put into the incubator and continued morning and night until the first egg pips. The turning periods should be as near twelve hours apart as possible. Perhaps the easiest and best way to turn is to use a rotary motion, rolling the eggs slowly with the palms of the hands. They will not break even if considerable pressure is used, provided they are not jarred or handled with sudden motions. The eggs do not have to be turned completely over. All that is necessary is that the eggs be shifted around a little so that the embryos will not stick to the shells.

Cooling.—The purpose of cooling is to thoroughly air the eggs and strengthen the embryos. It corresponds to the opening of the windows by the housewife each morning to air the bedroom. The incubator door should not be left open while eggs are being cooled. The aim is to cool the eggs, not the incubator. The hen's body temperature is the same when she returns to the eggs as it was when she left them. So it should be with the incubator.

In setting the eggs out to cool do not allow any part of the tray to project beyond the table or incubator, or the eggs will cool unevenly and those in the projecting part of the tray will become chilled by the time the others are ready to go back into the machine. Begin cooling on the seventh day and cool every evening when the eggs are turned. Cool a little at first and gradually lengthen the cooling period as the hatch advances. A most satisfactory way to tell when the eggs are cooled sufficiently is to hold the small ends of a few to the eye. When they feel barely warm the eggs are cooled enough. A little experience will make one expert in gauging the cooling period. They will cool down rapidly at first, but as the embryos develop and contain animal

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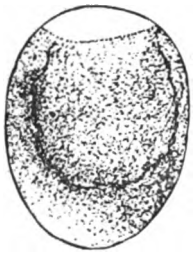
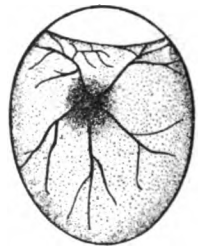
heat of their own they will cool down more slowly. In the month of May, twenty to sixty minutes is often required to cool eggs that have been in the incubator fourteen to eighteen days. The amateur usually errs on the side of too little, rather than on that of too much cooling.

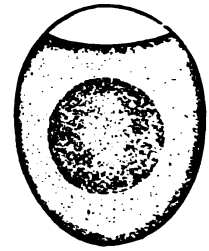
Testing.—Test on the seventh and fourteenth days, at night, because that is the time the cooling is done. The first test will remove all infertile eggs and dead germ eggs up to that period. The infertile eggs are still perfectly good and can be used in cakes. The writer has known them to be so used and considers them as good as cold-storage eggs for cooking purposes. The dead germs at the seventh-day test contain either blood clots or blood rings. Every egg in which a dark movable black spot, a little larger than a pinhead, with numerous radiating blood vessels is not distinctly visible should be discarded as worthless. Good, strong eggs only will hatch good, vigorous chicks.



Dead germ, seventh day



Fertile egg, seventh day



Infertile egg

Fig. 3

On the fourteenth day the strong eggs will be opaque and nearly black, and if such an egg can be held still before the tester, the embryo can be seen to move. Dead germs at this time contain either blood rings or blood streaks, or are perfectly translucent and cloudy.

The Hatch.—After the last turning, close up the incubator and do not disturb it again until the hatch is over, except to fill the lamp. As soon as all the chicks have dried off, open wide the ventilators, remove the egg tray and all the eggshells, and wedge open the door with a match stick so as to harden the little fellows, but do not let the temperature in the nursery go below 100 degrees F. Darken the egg chamber by hanging a cloth in front of the glass door to keep chicks from picking at the droppings and at each other's toes. After twenty-four hours remove them to the brooder in a flannel-lined and hooded basket. A chilling draught striking them at this time would prove disastrous.

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CIRCULAR No. 157
(NOVEMBER, 1916)

CONTROL OF PEAR SCAB

BY RALPH E. SMITH

This circular is published on account of the unusual prevalence of pear scab in California in 1916 and the fact that our bulletin 163 has

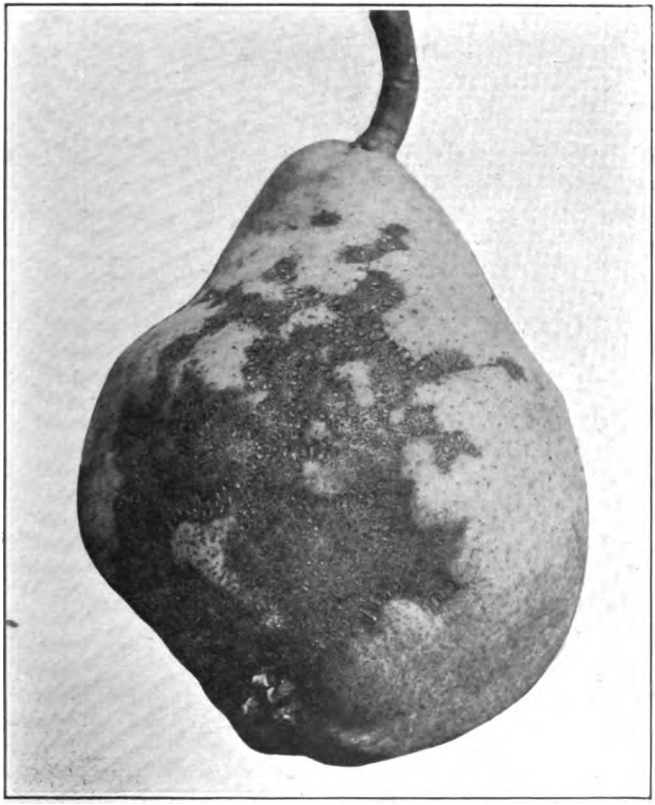

Fig. 1.—Pear scab.

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long been out of print. Growers who have observed the following directions explicitly year after year have had little or no trouble from scab.

1. Plow under dead leaves as thoroughly as possible.

2. Spray with Bordeaux mixture twice while the buds are unfolding, first when the leaf buds are just opening, as in Figure 3; second, a week or ten days later, just before the individual blossoms open, as

Fig. 2.—First stage in opening of pear tree buds. A little early for spraying.

in Figures 4 to 5. The first spraying is the more important, but both should be given.

3. In large orchards begin spraying when the buds are about like those which are open the least in Figure 3, so that if delays occur the trees will get at least one good spraying before it is too late. Spraying before the first stage, Figure 2, or after the last, Figure 5, will do little or no good in scab control, especially with Bartletts.

4. As an extra precaution, make a third scab spraying by mixing the first lead arsenate codling moth spray with Bordeaux mixture instead of plain water.

5. Spray with good equipment and high pressure, and cover the trees thoroughly, especially the twigs and buds.

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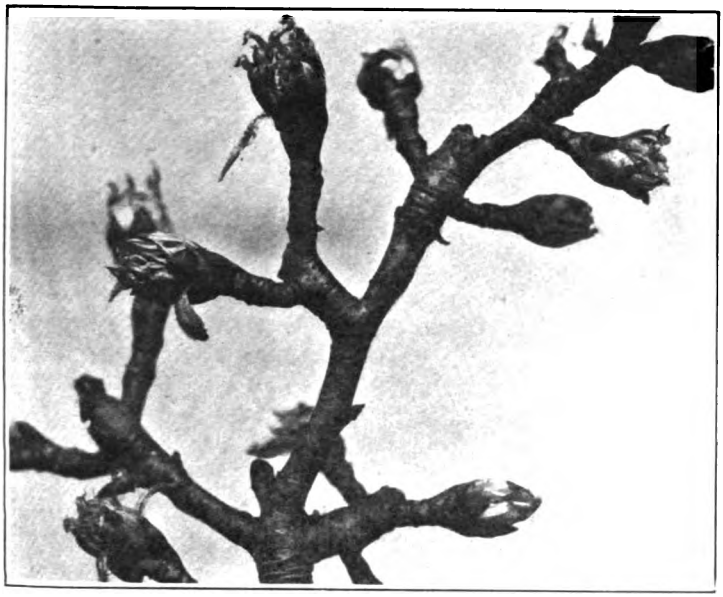

Fig. 3.—Further development of buds.

COMMENCE FIRST SPRAYING

Fig. 4.—Blossom buds appearing.

COMMENCE SECOND SPRAYING

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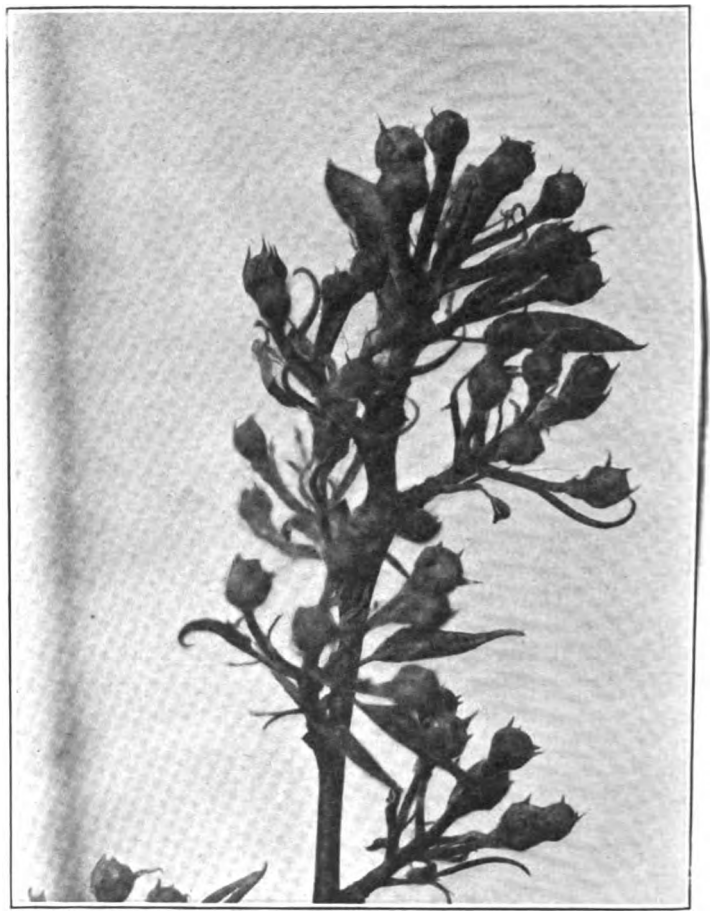

Fig. 5.—Blossom buds well out. Second spraying should be finished.

DIRECTIONS FOR MAKING BORDEAUX MIXTURE

Bluestone	20 lbs.
Quicklime	25 lbs.
Water	200 gals.

Dissolve the bluestone and slake the lime in separate vessels. Strain the bluestone into the spray tank and fill it half full or more with water. Strain in the lime mixed with the rest of the water. Always have the materials well diluted before mixing them together.

(*Note.*—If a third spraying, of lead arsenate combined with Bordeaux mixture, be made, the amounts of bluestone and lime may be reduced to 15 and 20 pounds, respectively.)

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CIRCULAR No. 158

DECEMBER, 1916

HOME AND FARM CANNING

BY W. V. CRUESS

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INTRODUCTION

For several years requests for information regarding the home canning of fruit and vegetables have been received at the station with increasing frequency. To supply this information it has been found

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necessary to test the various methods generally recommended. This has been done both with the appliances used in most homes and with a special canning outfit constructed for home and small-scale operations.[1] In the course of this work several useful new methods have been devised. This circular is intended to describe these new methods and also to give general information asked for by numerous enquirers.[2] For a more complete discussion of the principles involved, the reader is referred to the correspondence course in "Canning and Preserving," given by the Division of Agricultural Education of the University of California.

A large quantity of fruits and vegetables goes to waste every year or is sold at prices which return little profit. Much of this, while unsuited to the special requirements of the commercial cannery or drier, is well adapted for home use if properly canned. The quality may be as good or better than that of the product of the commercial canneries, if put up with the proper knowledge and care. It is often possible to find a limited market for home products of this kind at profitable prices.

Local and private markets are usually the most satisfactory for the home or farm canner. He will seldom find it profitable to sell on the general market through jobbers in competition with the commercial canneries. With careful attention to all the details of the work and a little business ability it will often be possible to make the home canning outfit a useful adjunct to the orchard and garden, and much of the work will be found agreeable and profitable by the women of the household.

Causes of Spoiling.—The principal aim of canning is to prevent the material from spoiling. Spoiling is not due directly to the action of air or of heat. It is not a simple chemical nor physical change. When vegetable matters ferment, decay or turn sour, it is because of the growth of certain microscopic, living organisms or "germs." These all belong to the vegetable kingdom and are divided into three groups: molds, yeasts, and bacteria. Familiar examples of each group are the blue-green mold of spoiled fruits, the yeast used in bread-making, and the bacteria of the scum and "mother" of vinegar. What we see in compressed yeast, for instance, is simply a mass consisting of millions of germs. Individual germs are too minute to be seen without a microscope. Their activities cause the molding of jellies, the swelling and souring of canned fruits and vegetables, and the ptomains of canned meats. The character of the material largely determines which type of spoiling will occur. Acidity is favorable

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to yeasts and molds. Fruits may therefore spoil by yeast fermentation or become moldy. Bacteria prefer a medium with little or no acid. When vegetables decay it is therefore usually due to the action of bacteria. Neither fruits nor acid vegetables are favorable to the growth of the bacteria which produce the poisonous ptomains sometimes found in spoiled meats.

Methods of Preserving.—The micro-organisms which cause spoiling come from the air or from the surfaces with which the material comes in contact. They can no more develop from non-living matter than wheat can appear spontaneously in soil devoid of wheat seed. In food preservation, we are dealing with living organisms, whose activities can be prevented in one of two ways: We may kill all the germs present by heat or other means and prevent the entrance of all others, or we may make the conditions so unfavorable to the germs that they cannot grow or do any damage. The latter way is followed when we impregnate meat with so much salt that bacteria cannot grow, or add so much sugar to jam that yeast cannot multiply. The heat method is utilized in most methods of canning.

Sterilization by Heat.—The killing of all germs present is called sterilization. In canning, this is accomplished by heating. The material to be preserved is placed in a vessel, jar, or can, in which it is sealed hermetically, i.e., made air-tight. It is then heated to a temperature fatal to all the germs it contains. No spoiling can then take place until the vessel is opened, as there are no means by which germs can enter.

Molds and yeasts, as they occur on fruit and vegetables, are quickly killed at temperatures several degrees below 212° F., the boiling point of water. In most cases, in fact, they are killed at temperatures of between 150° F. and 165° F. On the other hand, bacteria occurring on vegetables are much harder to kill, many of them withstanding the temperature of boiling water for an hour or more. These bacteria owe their astonishing resistance to the presence of spores. Spores are to bacteria what seeds are to higher plants and are resistant for the same reasons, viz., because of their thick, tough coats and low water content.

These bacteria, with resistant spores, probably occur also on fruits, but it is not necessary to kill them in this case, as they are very sensitive to acidity and therefore cannot grow in fruit juices. With vegetables the case is different. These, with the exception of tomatoes, have little or no acidity and are well suited to the growth of the heat-resistant bacteria. To sterilize vegetables it is therefore usual to heat

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the sealed cans to temperatures above 212° F. The temperature can be raised to 212° F. by placing the sealed cans in an open tank or pot containing boiling water. Under these conditions no higher temperature can be reached, as the evolving steam removes the excess of heat as fast as it is applied. In a closed space where the steam cannot escape, however, higher temperatures can be obtained. As the temperature rises the pressure increases. In canning vegetables, pressures of three to fifteen pounds to the square inch are generally used. This corresponds to temperatures of 221.3° F. to 249.1° F.; the higher the pressure the higher the temperature.

Temperatures of 230° F. and over can also be obtained by adding ordinary salt or calcium chloride to the water in which the sealed cans are heated. The salt raises the boiling point of the water.

Fractional sterilization.—Vegetables may also be sterilized by repeated heatings to 212° F. If heated to this temperature the ordinary bacteria are killed and the spores are softened so that they sprout easily and rapidly. If the heating is repeated therefore twenty-four or forty-eight hours later the sprouted spores are killed. A third heating after a similar interval usually destroys all spores.

New methods of sterilizing vegetables.—The high temperatures or repeated heatings used in the canning of vegetables are not only troublesome and expensive, but injurious to the flavor and texture. Experiments in the zymological laboratory have developed a very simple and certain way of sterilizing vegetables as easily as fruit. This consists in the addition of a little acid to the liquid in which they are canned. It was found that peas heated to 212° F. in a brine acidified by the addition of five ounces of lemon juice to every gallon, kept perfectly, while peas heated in the same brine without lemon juice spoiled. The same results were obtained with beans, pumpkins, beets, turnips, artichokes and asparagus. Large quantities of these vegetables are lost by "spoilage" in the commercial canneries. The flavor of the vegetables sterilized at the low temperature was much superior to that of those sterilized under pressure.

The common household practise of canning corn and tomatoes together owes its efficacy to the same principle. Corn alone is very difficult to sterilize, owing to its lack of acidity. This lack is supplied by the tomatoes and the mixture is easily preserved by ordinary heating. Doubtless other wholesome acids, such as vinegar, citric, or tartaric acid, could be used for the same purpose. The amount of acid used is small and improves rather than injures the flavor.

Sterilizing fruits at low temperatures.—Heating fruit to 212° F. always changes more or less the flavor, texture and appearance. In

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a few cases, the change of flavor, due to cooking, may be an improvement, but in most cases it is desirable to retain as much of the original character of the fruit as possible. This is accomplished by careful handling and by heating to the lowest temperature that will insure sterilization. Experiments continued for two years at the zymological laboratory have shown that certain fruits can be safely sterilized at temperatures of from 165° F. to 175° F. Peaches, apricots, pears, cherries, and berries have been successfully preserved after sterilizing at these temperatures, and have retained much more perfectly the texture and flavor of the fresh fruit than when subjected to the higher temperatures generally used in canning. The improvement with peaches was particularly marked.

In this method the cans are filled with fruit in a fairly heavy syrup—30°–50° Bal—(See page 16); exhausted three minutes at 150° F.; tipped and placed in hot water kept at 175° F. They are left in this water for ten to twenty minutes with occasional stirring to hasten the penetration of the heat. They are then removed and allowed to cool.

Preservatives.—Food materials can be prevented from spoiling by the use of certain substances known as preservatives. Some of these are injurious to health and forbidden by the pure-food laws. Others are not encouraged by pure food laws, because they are used by unscrupulous manufacturers to cover up defective materials or careless methods of manufacture.

Certain preservatives, however, are useful and permissible. For fruits, sugar is the most commonly used. If the sugar content of fruit juice, jelly or jam is raised to 65° Bal. by evaporating part of the water, or by adding sugar, they become unsuitable to the growth of micro-organisms and will keep even in open vessels. This is why dried fruit does not spoil and why jam must be made sweet.

For vegetables, salt is extensively used, as in preserving olives in barrels and in keeping certain types of pickles. Vinegar and spices are used in the same way. Sometimes a combination of the effects of heat sterilization and preservatives is used as in the new method of preserving vegetables described above. Heating to 212° F. destroys the molds and yeasts and the addition of citric acid prevents the growth of bacteria.

Methods of Home Canning.—The principles and theory of canning are the same whatever the scale on which it is done. The differences are only in the mechanical details of the methods of applying these principles.

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There are two general methods in use. In one, known as the "Hot-pack method," the material is cooked in open pots and poured while hot into the cans, together with the hot brine or syrup. The cans are sealed immediately and sterilized. In the other, the "Cold-pack method," the freshly prepared material is placed cold in the cans and then covered with the hot syrup or brine, sealed and sterilized. The material is always hot when the cans are sealed. Only the cold-pack method is described here, as it is generally the best, especially for home use.

a *b* *c* *d* *e* *f* *g*

Fig. 1.—Common kitchen utensils useful in home canning: (*a*) Dishpan for peeling receptacle, etc.; (*b*) pots of various sizes; (*c*) small scale; (*d*) measuring cup; (*e*) peeling knives, spoons, and small utensils; (*f*) five-gallon pot for syrup; (*g*) collander or strainer.

OPERATIONS, MATERIALS AND EQUIPMENT

General equipment.—Most of the utensils and materials needed in home-canning are to be found in all kitchens. They include a good stove, or other means of heating, a large table for the preparation of materials, a sink and good supply of water, various agateware pots, saucepans, and buckets, large cooking spoons, and a sufficient supply of sugar and salt. To these should be added a good thermometer, suitable for placing in liquids, and reading from at least 32° F. to 250° F. (cost, about $1.00). A Balling or Brix saccharometer or sugar tester is also very useful. It should read from 0 per cent to 70 per cent and costs about 75 cents. For use with this will be needed

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a tin cylinder to hold the liquids to be tested. It should be about 1½ inches in diameter and about 12 inches long. (See page 14.) The thermometer and saccharometer can be obtained through a drug store.

Other necessary or desirable materials are described in the following paragraphs. If the canning is to be done on a somewhat larger scale for the market it will often be advisable to purchase a factory-made outfit which may be obtained in various sizes.

Jars.—Glass jars are preferable to tin cans for home use. They can be used repeatedly; they present no danger from tin poisoning and the contents are more attractive in flavor and appearance. Their greater initial cost is offset by these advantages. Where the product is to be sold, it is usually necessary to use cans unless special high quality is demanded and a price sufficient to cover the extra cost of jars can be obtained. One commercial cannery in California owing its success to the high quality of its fruits preserves them principally in glass.

Glass jars are to be found in a variety of sizes and shapes and with various methods of hermetic sealing. The sizes most used are pints and quarts and to a smaller extent half-gallons. The only important variation in shape is the width of the mouth which may be as wide as the jar or only about half its width. The commonest method of sealing is by means of a rubber ring which fits between the cover and the top of the jar.

In the Mason jar and its various modifications the cover is a screw cap which makes an hermetic joint when screwed down on the rubber ring. In the ordinary form this cap is of zinc with a porcelain lining. This is the commonest and cheapest form. Wide-mouth Mason jars are now made which are very convenient for large fruits. They have enamelled metal caps which are often difficult to remove and may be broken in opening the jar.

In another common form, of which the Atlas is an example, the cover is a glass disc held in place and pressed down on the rubber by means of a strong wire clamp. After the fruit cools the clamp may be removed and the cover will be held in place by the vacuum. This affords a convenient means of detecting spoiled jars. If there is any fermentation of the fruit the gas formed will fill the vacuum and the cap will be loosened. This is a very convenient and durable form of cover and there are no metal parts in contact with the fruit.

Vacuum Seal glass jars are used in jelly and preserve factories. They have an enameled metal cap resting on a heavy, soft rubber ring and held in place by a vacuum inside the jar. This vacuum is pro-

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duced in factories by means of an expensive machine. For home use these jars may be sealed by forcing the caps on by hand, while the contents are hot. On cooling, a vacuum is produced which holds the caps firmly in place.

In all cases where rubber is used in sealing it must be specially treated, as it will otherwise give a disagreeable taste to the food. Fruit and vegetables are often completely spoiled by this taste. It can be avoided by thoroughly treating the rubbers with a hot alkaline, followed by a hot acid solution. They are first boiled for several hours in water made alkaline with two or three tablespoonfuls of washing soda to the gallon. They are then rinsed and boiled a second

a *b* *c* *d* *e*

Fig. 2.—Types of jars used in home canning: (*a*) Removable clamp and glass top; (*b*) fixed clamp and removable glass top; (*c*) lacquered metal clamp top: (*d*) wide mouth screw top of lacquered metal; (*e*) ordinary narrow mouth screw top, with porcelain or glass-line cap.

time in water made slightly acid with lemon juice or vinegar. A third short boiling in plain water fits them for use.

In some forms of jars, the rubber ring is replaced by a ring or disk of pasteboard treated or varnished. These are not commonly used and are less generally suitable.

A commoner type that avoids the use of rubber is the Economy jar and its modifications. The cover is an enameled metal disc around the end of which runs a small groove filled with a hard wax-like compound. When the jar and its contents are heated this compound melts and seals the cover to the jar when it cools and hardens. A metal spring holds the cover in place until the compound hardens and may then be removed.

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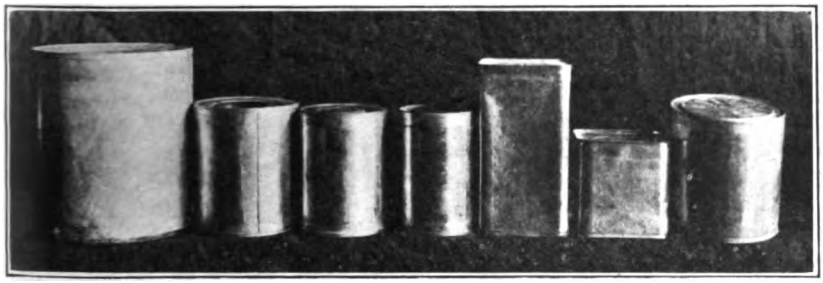
Cans.—There are three general types of cans used for fruit and vegetables—the "wax-top," the "solder-top," and the "sanitary."

With the *"wax-top,"* the cover is sealed on by means of a ring of hot sealing-wax. It is suitable for use with fruits and tomatoes, but it is not satisfactory for most vegetables, which require high temperatures necessary. They are easily manipulated and require no special equipment.

"Solder-top" or "stud-hole" cans with the necessary soldering tools are used in the factory-made home canning outfits and can be used with any outfit. The top of the can has a circular opening varying in width with the size and type of cans. After filling the



a *b* *c* *d* *e* *f* *g*

Fig. 3.—Types of cans used in home canning: (*a*) No. 10 or gallon solder top can; (*b*) No. 3 solder top can; (*c*) No. 2 solder top can; (*d*) No. 1 tall solder top can; (*e*) No. 2½ square tall solder top can for asparagus; (*f*) small square solder top can for asparagus; (*g*) wax top can.

can, this opening is closed by soldering on a tin disc. This disc is usually perforated with a small hole to allow steam to escape during the preliminary heating. This hole must be closed with solder before the final sterilization.

"Sanitary-cans" used in large canneries are not sealed with solder. The cover or cap is "crimped" on by means of a special machine. There is a "composition" coating on the cap where it comes in contact with the can which makes the sealing doubly sure. The necessary machine is expensive and not suited for home use. A cheap hand-power machine can be obtained, but according to Dr. Bitting of the National Canners' Laboratory, its work is not satisfactory.

Cans are to be obtained which are coated inside with a protective enamel. These are suitable for very acid fruits, rhubarb and beets, as they minimize the action of the acids on the tin.

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The capacity and dimensions of the cans most used for fruit and vegetables are given in the following table:

DIMENSIONS AND CAPACITY OF USUAL CANS

	SANITARY			SOLDER TOP	
Number	Height	Diameter	Capacity	Height	Diameter
1	4	2 3/4	11.6	4	2 1/16
2	4 1/2	3 3/8	21.3	4 9/16	3 3/8
2 1/2	4 11/16	4	31.2	4 3/4	4
3	5	4 1/4	35.0	4 7/8	4 3/16
10	6 15/16	6 1/8	107.0	6 7/8	6 1/4

Outside dimensions in inches.
Capacity in fluid ounces.

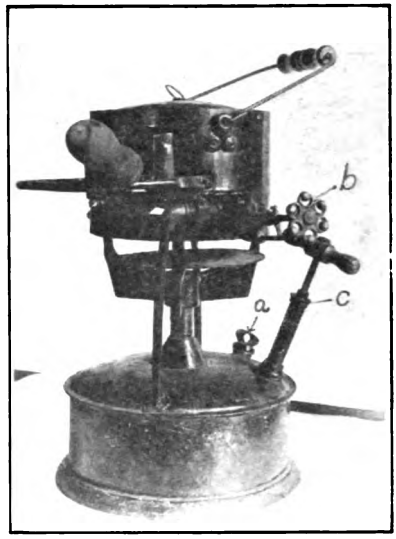

Fig. 4.—Gasoline torch used in heating capping and tipping steels: (*a*) Inlet for gasoline; (*b*) burner cock; (*c*) air pump.

In commercial canning, No. 2½ cans are commonly used for fruits and tomatoes, No. 2 for peas, beans and corn, and square No. 2 for asparagus. Apples and "pie" grades of fruit are usually put in No. 3 or No. 10 cans. Many other sizes and shapes are used for special purposes.

Soldering Material.—To fasten the caps on the cans, a *"capping steel"* is needed. This is a cylindrical soldering iron with a concave end to fit over the cap with which it must correspond in size. *Solder-hemmed caps* are furnished with a ring of solder. Their use saves much time, labor and solder. The small vent hole is sealed with a *"tipping-steel"* which is a small, pointed soldering iron. (See fig. 5.)

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In order to make a good union between the solder and the tin, the surfaces must be cleaned with a *"soldering flux."* This can be bought ready for use or can be prepared as follows: Place about one ounce of zinc in half a tumbler of strong muriatic (hydrochloric) acid and leave until bubbles cease to come off. If all the zinc dissolves add more until a little remains after all bubbling ceases. The solution is then strained through a cloth. It will keep indefinitely and must be diluted with an equal volume of water before using.

A gasoline *fire pot* or *torch* of the type used by plumbers is needed to heat the soldering irons. One like that shown in Fig. 4 or smaller is satisfactory.

Starting the torch.—The reservoir of the torch is filled about three quarters full of good gasoline. The air pump is screwed into place (see Fig. 4*c*), and air pumped in to give as much pressure as possible.

The cocks of the two burners (see b, Fig. 4), are then opened very slightly to allow a little gasoline to flow out and wet the burners. They are then closed and the burners heated by burning off the gasoline. This process is repeated once or twice until the burners are hot enough to vaporize the gasoline rapidly.

When the burners are sufficiently hot, the cocks are opened a little and the gasoline lighted. The flame should burn with a blue color and a roaring sound. The torch is then ready to heat the steels.

Tinning the capping steel.—The steel is heated sufficiently to melt a piece of solder instantly, but not to burn it. The bottom of the steel, both inside and out, should then be cleaned by filing off the scale. It is then dipped quickly into a little of the soldering flux and "tinned" by applying wire solder which should melt rapidly and cover the bottom of the steel with a bright metallic layer. This layer should extend to about one-half an inch from the bottom. The steel may also be tinned by filing it clean while hot and dipping into a mixture of sal ammoniac and small pieces of solder.

This process need not be repeated until the steel becomes accidentally too hot and burns off the "tinning." If the steel is wiped occasionally while hot with a coarse cloth and dipped regularly into the soldering flux when used the coating should last indefinitely.

Soldering the Cap.—The grooves around the tops of the filled cans are wiped to clean them from juice and pieces of fruit and the caps applied. A brush dipped in solder flux is then passed around the groove. The capping steel, heated until it will melt solder instantly, is cleaned by dipping in solder flux and applied immediately to the groove of the can. If plain caps are used, a little solder is melted around the bottom of the steel and allowed to run into the groove.

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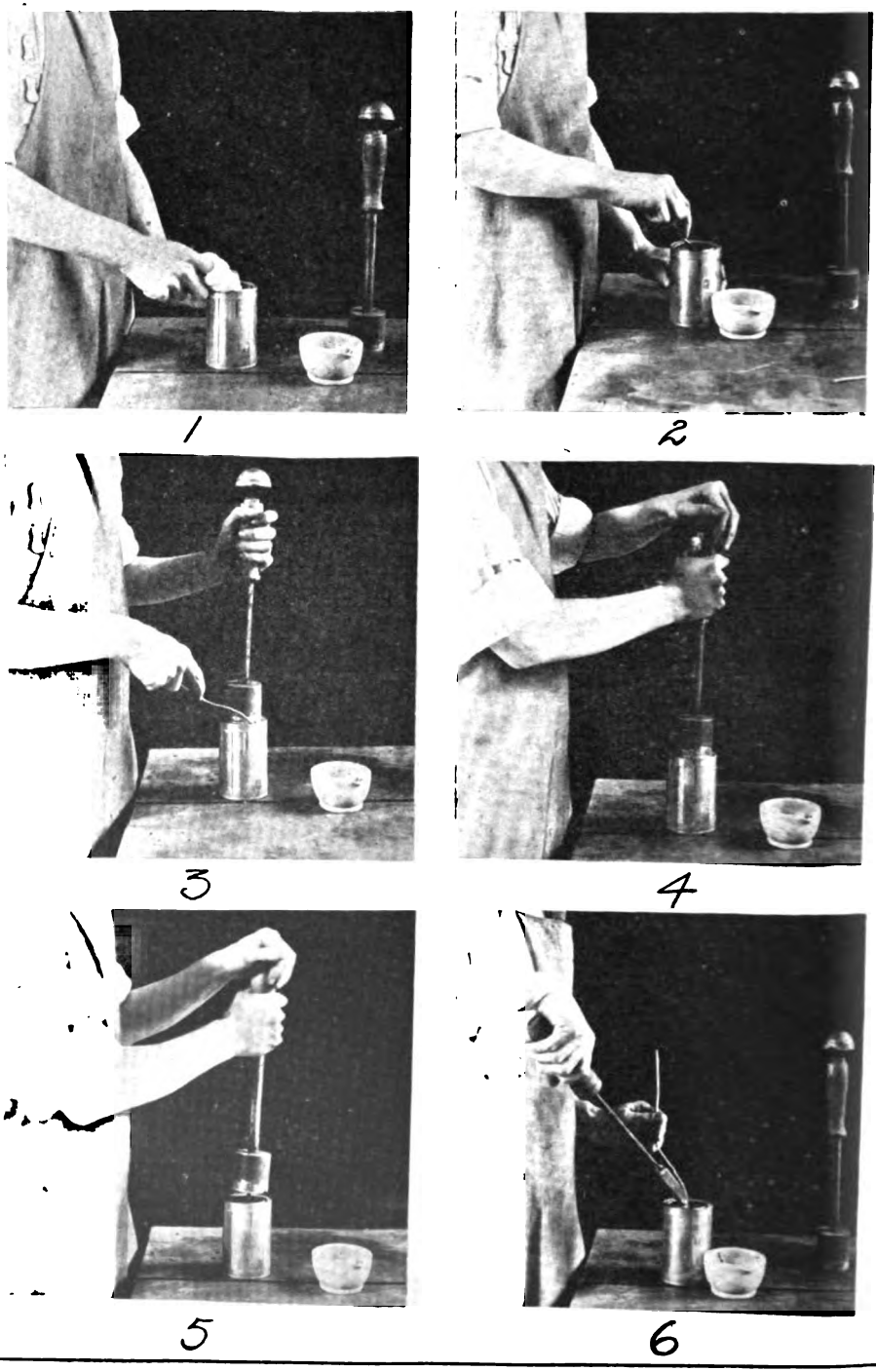

Fig. 5.—Sealing a solder top can. (For description see opposite page.)

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Only a little is necessary. If solder hemmed caps are used no other solder is needed. The steel is turned a few times to distribute the melted solder evenly in the groove and then slightly raised while pressing down on the center rod for an instant until the solder hardens. (See Fig. 5.)

Tipping.—This term means the closing of the small vent hole in the top of the can with a drop of solder. It is done while the contents are hot and before sterilizing. The edges of the holes are cleaned with a brush dipped in solder flux. Very little must be used or it will run into the can and injure the contents. After applying the flux, the properly tinned and heated tipping steel is applied to the

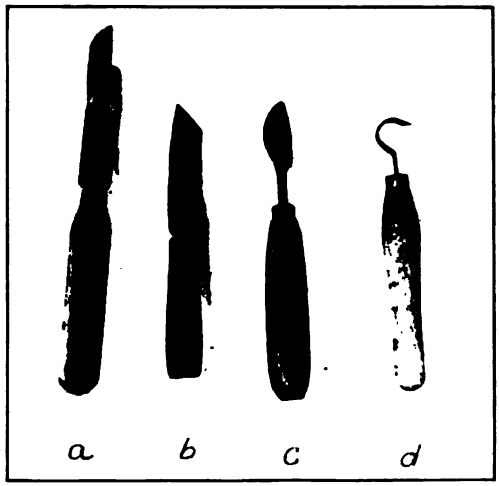

Fig. 6.—Knives used in canning: (*a*) Peeling knife; (*b*) cutting knife; (*c*) peach pitting spoon; (*d*) pear coring knife.

hole and touched with a piece of wire solder. This causes a small drop of melted solder to run to the point where it closes the hole and is smoothed by a quick twist of the steel. (See Fig. 5.)

Preparation of material.—Nearly all fruits and vegetables require some kind of preparatory treatment before canning. They may

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Fig. 5.—Sealing a solder top can.

1. Wipe the juice and syrup from the groove.
2. Apply cap and wipe the groove with a brush dipped in soldering fluid.
3. Place clean hot capping steel on can and melt a little solder into groove.
4. Turn the hot steel to distribute the solder.
5. Press down on center rod, and raise steel a few seconds to allow solder to harden.
6. After exhausting can wipe vent hole and seal vent with a drop of solder.

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require washing, sizing, sorting for color or ripeness, peeling, pitting, coring or slicing. Each requires special treatment which is described later. In some cases special machines or tools are necessary. Some simple tools generally useful are shown in Fig. 6. These are (*a*) a knife fitted with a guard to prevent excessive waste of pulp in peeling, and a broad knife (*b*) for cutting and slicing. For clingstone peaches a special spoon (*c*) with sharp edges is used. This is forced into the peach from the stem end and given a rotary motion which cuts the pit from the flesh and permits its extraction. A curved spoon or knife (*d*) is used for removing the cores of halved pears.

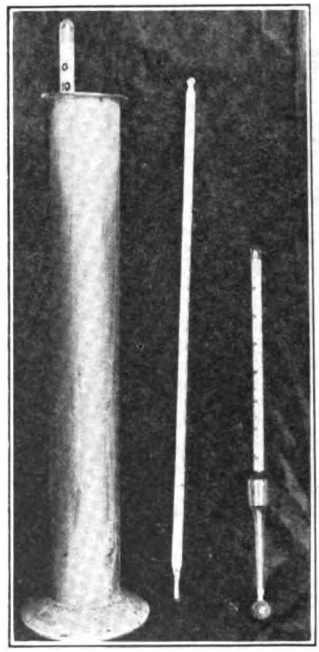

Fig. 7.—Tin cylinder, thermometer, and Balling sugar tester. The tester in the cylinder of syrup is read at the surface of the liquid. In the above case, this is approximately 12 per cent.

Blanching.—Certain vegetables should be "blanched" or parboiled before canning. This is done by dipping them in boiling water. A wire screen basket or a frying basket, such as is used in cooking doughnuts, will serve to hold the vegetables while they are dipped in a large cooking pot containing boiling water. This treatment

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improves the quality, by removing slimy matters and lessening the astringent taste of the skins. It is necessary with asparagus to remove bitterness.

Exhausting.—This process is necessary with nearly all air-tight containers which are to be sterilized by heat. It consists of a preliminary heating before sealing and before the final sterilization. It results in expanding the air inside the container and thus driving out most of it. When the sealed container and its contents cool, the small amount of air still enclosed contracts and produces a partial vacuum. If cans are sealed while the contents are cool they will swell on heating, owing to the expansion of the heated air. Exhaustion is also necessary with jars. If the covers are screwed or clamped on, the expanding air may break the glass. If they simply rest on the rubber or other sealing ring the vacuum is necessary to keep them in place.

If the fruit is hot when placed in the cans or jars they may be sealed and sterilized immediately as the heat will exhaust the air sufficiently.

Syrup.—Fruits are canned in sugar syrups of various strengths or concentrations. In general, the more acid fruits require the most sugar. The appropriate strengths are given in the directions for canning the various fruits.

Brix or Balling sugar testers.—Syrups of the desired strengths may be made up by weighing the sugar and measuring the water, or by adding sugar to the water until the desired strength is indicated by the sugar tester or hydrometer. This is sometimes called a saccharometer and the commonest forms are the Brix and the Balling. The hydrometer is floated in the syrup contained in a tall, narrow metal or glass cylinder and the per cent of sugar read off from the scale at the surface of the liquid. If the syrup is cold the reading is correct enough for the purpose, but if very hot the reading may be 4 per cent too high. (See Fig. 7.)

Baumé sugar tester.—This is a hydrometer similar in form to the Brix, differing only in the scale, which reads in degrees instead of per cents. The degrees may be multiplied by two to give the per cent approximately.

Strengths of Syrup.—By carefully measuring the sugar and water, syrups of any desired strengths can be made up. The following table shows the relation between the sugar per cent, the Baumé degree and the proportion of sugar and water:

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SUGAR SYRUPS

Per cent of sugar (Brix or Balling)	Baumé Degrees	Weight of sugar Per 1 gal. of water
5	2.8	0 lbs. 7 oz.
10	5.5	0 15
15	8.3	1 8
20	11.1	2 2
25	13.8	2 13
30	16.5	3 10
35	19.2	4 7
40	21.9	5 10
45	24.6	6 14
50	27.2	8 6
55	29.8	10 4
60	32.4	12 10
65	34.9	15 11

In making up syrups from this table, the weight of sugar in the last column opposite the desired per cent or degree is added to each gallon of water and dissolved by warming and stirring. The volume of syrup obtained is greater than that of the water used. The increase of volume is very slight with syrups of 5 per cent to 15 per cent, but is greater with more concentrated syrups; 15 pounds 11 ounces of sugar and one gallon of water giving nearly two gallons of syrup at 65 per cent.

Cane and Beet Sugar.—In numerous tests made by Dr. Bitting of the National Canner's Laboratory, by G. W. Shaw, formerly of the California Agricultural Experiment Station, by the Enology Laboratory, and by others, beet sugar was found to give results equal to those of cane sugar. The prejudice against beet sugar may have been warranted when the methods of manufacture were crude, but it can now be produced in as pure a state as cane sugar with which it is identical chemically.

Brines.—Most vegetables are canned in a light brine with or without addition of a small amount of sugar. The desired strength of brine is obtained by adding a weighed amount of salt to a measured volume of water. The number of ounces of salt to be added to a gallon of water for brines of various concentrations is given in the following table:

BRINES

Per cent of salt in brine	Ounces of salt per gal of water
1	1⅓
2	2⅔
3	4
4	5⅓
5	6⅔
10	14¼
15	22⅔

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Sterilizers.—A sterilizer is a covered vessel in which the filled cans or jars are heated to the degree and for the time necessary to sterilize their contents. The sterilizer containing the cans and several inches of water is placed on a stove, and steam generated by boiling the water heats the cans. The cover must be sufficiently close to insure steam heat in all parts of the vessel, but must not be too tight, or the steam pressure will cause the vessel to burst. An ordinary wash boiler fitting the top of a kitchen stove can be made to serve as a very satisfactory home sterilizer. A piece of heavy wire screen of half-inch mesh and cut to fit should be placed in the bottom. This will serve to

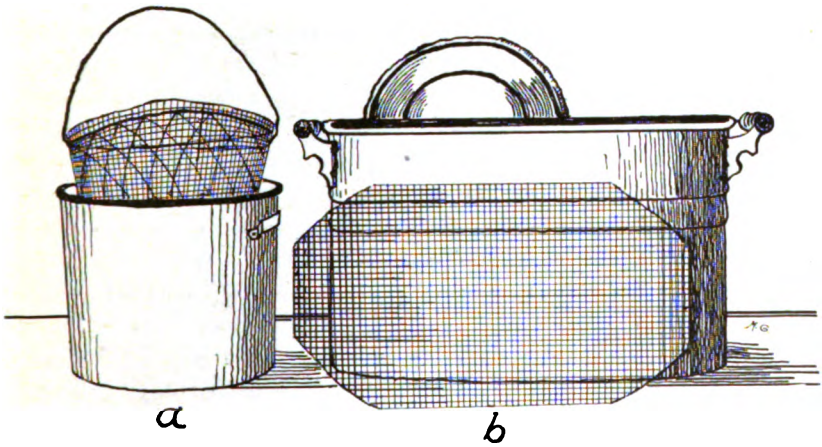

Fig. 8.—Apparatus used for blanching vegetables and sterilizing fruits and vegetables. (*a*) Blanching basket and pot; (*b*) wash boiler sterilizer, showing screen used as false bottom.

keep the jars from contact with the bottom of the boiler, where they might break if too close with the fire. (See Fig. 8.)

The water in the boiler should reach to within a couple of inches of the top of the jars. Cans may be placed in two or more tiers, separated and supported by slat gratings which allow the steam to penetrate to all parts of every can. The cover of the boiler should fit snugly in order that the steam will be confined and heat the upper part of the sterilizer to the boiling temperature.

Pressure Sterilizers.—Certain vegetables are hard to sterilize except at very high temperatures. Sterilizers using pressure steam will attain these temperatures and the cheapest forms can be bought for about ten dollars. For family use these are unnecessary, the methods

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described on page 4 being more convenient, as they require no special equipment.

Where vegetables are to be canned for sale it will usually pay to obtain a pressure cooker, as they are fairly easy to operate. Directions for operating accompany the outfits.

The pressure cooker is fitted with steam gauge, thermometer, release cock and safety valve, and with weight and lever to regulate the pressure. In using, the boiler is first one-fifth filled with hot water. The cans filled, capped and tipped in the usual way, are then placed in the crate and lowered into the boiler. The cover of the cooker is now screwed down, but the *release cock is left open.* Heat is then applied until steam escapes freely from the open cock. This cock is then closed and heating continued until the temperature reaches the desired point. At this point the safety valve should be set for the corresponding pressure (see table). At the same time the release cock is opened slightly, so as to allow a small escape of excess steam. By this means the temperature can be regulated very exactly. The safety valve will open and relieve the pressure if the temperature commences to go too high and it cannot go too low so long as the small escape of steam continues through the release cock. When the heating has continued for the required time, the cooker is removed from the fire, the release cock opened, and when the pressure has fallen to 0 the cans are removed and cooled in water, or the steam may scald the operator. If the cooker is opened before the pressure has fallen to 0 the cans may burst. The larger outfits of this kind are equipped with a small steam boiler for heating, and three or more cookers.

TEMPERATURES F. CORRESPONDING TO LBS. STEAM PRESSURE

Lbs. press	Deg. F.	Lbs. press	Deg. F.	Lbs. press	Deg. F.
1	215.2	6	229.5	11	241.0
2	218.3	7	231.9	12	243.1
3	221.3	8	234.3	13	245.3
4	224.2	9	236.6	14	247.3
5	226.9	10	238.8	15	249.1

Marking.—All containers should be plainly marked with the variety and grade of the product. This can be done by means of a small set of rubber stamps and ink, such as that used by canners, which will stand hot water. They may also be marked after sterilization with gummed labels or wax pencils specially made for writing on tin and glass.

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SPECIAL DIRECTIONS FOR VARIOUS FRUITS

Apples.—Apples are canned almost exclusively for use in pies. Any sound fruit will do for this purpose, but Californian commercial canners are limited largely to yellow Bellflowers, yellow Newtowns, and Gravensteins, as these are the chief varieties grown in the state and available culls are chiefly of these varieties. The fruit should be firm and free from bruised spots. Tart apples are to be preferred.

Peeling.—The hand-power peeling and coring machine used in preparing apples for drying can be used if the blade that cuts the apple into thin discs is removed. The peeled and cored fruit is quartered and placed at once in jars or cans. From 20 to 40 per cent of the fruit is removed as peeling and cores. These can be used as jelly material.

Grading.—Two grades are made, the perfect quarters of good size comprising the first grade, and the small and imperfect quarters the second.

Syruping—Cans of fruit are filled at once with boiling water. Jars, to avoid breakage, are filled with water at 150° F. No sugar is used with canned apples ordinarily, because they are usually made into pies before eaten.

Capping and Tipping.—Put the cap in place and seal with the capping steel, then "tip" at once as directed on page 13. If the cans have been filled with hot water, no exhausting is necessary.

Processing or Sterilizing in cans.—Place the cans in the sterilizer of boiling water. If No. 3 cans are used, keep in boiling water 12 to 15 minutes, according to the ripeness and softness of the fruit. If No. 10 cans are used, 15 to 18 minutes are necessary. The same times are sufficient where the heating is done by steam in a closely covered boiler, where no steam pressure is developed.

It will be found convenient to have a number of crates made of heavy wire screen reinforced with iron straps to fit the sterilizer, to hold the cans during sterilizing. One of these can be filled while a full one is in the heater.

Cooling.—As soon as sterilization is complete, remove the cans and cool in a tub or tank of cold water to stop further cooking. If the screen crates mentioned above are used, they may be lifted from the sterilizer with the cans and the whole plunged into cold water.

Marking.—Some sort of an identifying mark should be placed on the cans with canners' ink before or with special pencils immediately

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after sterilizing and cooling. Some such mark as A–1 for first grade, and A–2 for second grade on the bottom of the cans will serve to identify them.

Storage and Spoilage.—Before any canned fruit is put on the market, it should be stored at least a month to see if it will show spoilage. It is better to have cans spoil in the store room than on the grocers' shelves. If the fire used to heat the sterilizer is not strong enough, it may take too long to bring the cans to the temperature of boiling water and the "germs" that cause spoilage may not be killed. Usually, however, the trouble is due to leaks in the cans. With an inexperienced operator, leaks often occur around the solder groove of the cap. When the capping operation is well done, there should be very few leaks. Leaks can be detected by bubbles appearing when the cans are dropped into hot water. Leaks permit air to get in and the air brings with it "germs" which cause the fruit to ferment and produce the gas that causes the cans to swell. There should be little spoilage with apples, as they are easily sterilized.

Sterilizing in jars.—Prepare as for cans. The peeled, cored and quartered fruit is placed in the jars which are then filled with boiling water to about three-eighths of an inch of the top. Put the rubbers in place and cover loosely with the caps. Rubbers should be boiled in water with one teaspoonful of baking soda per quart for at least one hour and then soaked for one hour in plain water before using. Otherwise a "rubber taste" may be given.

The jars are then placed in the sterilizer containing water near the boiling point. The water should come to about one-half the height of the jars and there should be a grating or screen between bottoms of the jars and the bottom of the boiler. A slat grating may be placed on top of the first tier of jars and another tier placed on top of this.

The cover of the cooker should fit tight and the water be boiled as quickly as possible. After boiling rapidly for twenty minutes, remove the jars and screw or clamp the caps down tight while the jars are still very hot. Then stand the jars upside down to cool in a quiet place free from draughts.

Apples in Syrup.—Apples to be used as dessert for home use may be canned in a heavy syrup. A 50 per cent syrup is used, made by dissolving one pound of sugar in each pint of water. It should be fairly clear. The peeled, cored and quartered apples are placed in the syrup and boiled slowly in a covered pot until they are cooked sufficiently. This is when they are still firm, but not hard. They should be more or less transparent.

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The fruit and syrup are then transferred to cans or to jars first heated in water. The cans and jars are then closed and sterilized, as above, except that sterilization for 5 minutes is sufficient.

Apples in Boiled Cider.—Instead of sugar syrup, "boiled cider" may be used. This is prepared by boiling down apple juice until it is reduced in the proportion of five gallons of fresh juice to one gallon of boiled cider or syrup. All the operations of canning are the same as with sugar syrup.

Pears.—The Bartlett is the best variety for canning purposes. It should be of good size and prime ripe, but not too soft. The fruit is peeled by hand and cored by the coring knife shown on page —.

Grade into Extra Fancy, Fancy and Pie grades after peeling. Cover with hot, 50 per cent, 30 per cent syrups and water, respectively. As pears tend to turn brown rapidly after peeling, they should be placed in the can with syrup as soon as peeled or should be kept under water after peeling until used. As soon as the cans are filled with hot syrup, cap them and tip. Sterilize No. 2½ or No. 3 cans in boiling water or steam at 212° F. for 20 minutes. If sterilized in glass, proceed as with apples, but sterilize for 30 minutes after the water reaches the boiling point.

Peaches.—For canning, peaches must have a good flavor which remains after heating; the texture must be close and the fiber tender; the color should be even and the ripening uniform from surface to pit. Of the cling varieties, the Tuscan and Phillips are very satisfactory and of the freestone, the Muir and Crawford are preferred.

Fruit for canning must be thoroughly ripe in order that the best flavor may be obtained. It may be graded into Extra Fancy, Fancy and Pie fruit before peeling.

Peaches are easily hand-peeled by the use of the peeling knife shown in Fig. 6. Freestones are easily pitted by cutting in half. Cling stones are pitted after peeling by inserting a pitting spoon from the stem end, and rotating it close to the pit. This cuts the pit loose from the fruit. The fruit is then cut in half. The pitting spoon is shown in Fig. 6.

Place in jars or cans and cover the Extra Fancy with a hot 60 per cent syrup, the Fancy with a hot 40 per cent syrup, and the Pie Fruit with water. Then cap and tip.

Freestone peaches require a shorter time of cooking than clingstones owing to the firmness of the latter. Sterilize clings in No. 2½ or No. 3 cans, twenty minutes at 212° F., and freestone peaches fifteen minutes at 212° F. Gallon cans will require thirty to thirty-five minutes. Cool the cans in cold water immediately after steril-

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izing. As peaches vary greatly in texture, the times given above are only approximate and must be varied according to the judgment of the canner. It is advisable to run a few trial sterilizations on one-can lots to determine the exact time necessary to give the desired texture to the finished fruit.

In quart or pint jars, Clings should be sterilized thirty minutes or longer at 212° F. and freestones twenty-five minutes. It is also recommended that tests be made on one-jar lots to determine the exact time necessary to give the best results. Peaches in jars, if for the market, should be made attractive by careful arrangement.

Fig. 9.—Funnel for filling fruit and syrup into jars or cans.

Vertical rows may be built up in the jars if the halves are not too large. Peaches are the most popular of any of the fruits canned. If carefully selected, graded and canned in a heavy syrup, and attractively labeled, there should be little difficulty in disposing of them at a profit.

Commercially, peaches are peeled by dipping in lye to soften the skins and then removing the skins by a strong spray of water. This method is not recommended for home canning, because the machinery required is too elaborate for small scale work.

Apricots.—Apricots for canning should be ripe and well colored, but not too soft. Many canners make the mistake of canning apricots too green. The canned product from such fruit has a "green" astringent taste that no amount of sugar can wholly overcome. If

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over-ripe, on the other hand, the fruit cooks down to a jam of unattractive appearance.

Grading.—The fruit should be sorted into three grades before pitting. These grades are *Extra Fancy,* consisting of full sized, prime ripe, well colored fruit; *Fancy,* consisting of sound fruit of fairly uniform and medium size, which may be a little too ripe or a little too immature to go into the Extra Fancy grade or which may have slight blemishes due to scab, etc.; and a third grade, known as *Pie Stock,* which would include soft over-ripe, small, immature and badly blemished, though sound, fruit.

Filling the Cans or Jars.—The fruit should be pitted immediately after grading. To remove the pits the apricots are cut in half with a fruit-cutting knife. The halved fruits are at once thoroughly washed in clean cold water to remove dust and dirt. They are then packed into enameled or lacquered cans or glass jars The fruit should be packed uniformly and the cans filled full, but not overfull. Jars for market should be packed only with the extra fancy fruit which should be arranged in perfectly straight vertical rows in halves of uniform size and color one above the other. Jars packed in this way are very attractive.

Addition of Syrup.—Apricots require a heavy syrup to bring out their best flavor. For the Extra Fancy use a syrup of 60 per cent sugar (60° Brix or Balling = 32½° Baumé); for the Fancy grade a 40 per cent syrup, and for the Pie grade only pure water.

Sterilizing in Cans and Jars.—Sterilization is conducted exactly as with apples (see page 19) except that a little longer heating is needed. The time of heating in the boiler depends on the size of the cans. For No. 1 and No. 2 eight minutes after the water boils is sufficient; for No. 2½ and No. 3, ten to fifteen minutes while No. 8 and No. 10 cans require twenty to twenty-five minutes. Jars are heated for thirty minutes in boiling water.

Cooling.—The cans are cooled in water and the jars in the air while standing upside down, exactly as with apples. Quick cooling prevents overcooking and injury to the flavor.

Sterilizing at lower temperatures.—The apricots are prepared in the way described and put in cans with a 50 per cent syrup heated to 165° F. The temperature must be verified with an accurate thermometer. The cans are sealed and tipped in the usual way and then immersed in a pot or boiler of water kept exactly at 175° F. No. 2 cans must be kept at this temperature for fifteen minutes, No. 2½ and No. 3 for twenty minutes. The temperature must be closely watched by means of a thermometer kept constantly in the water. If the tem-

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perature falls on inserting the cans the time is counted only after it reaches 175° F. The cans on removal are not cooled in water. Left in the air they cool slowly and complete the sterilization.

Apricots put up in this way have more of the fresh apricot flavor than when sterilized at 212° F.

Plums.—This fruit is canned whole in glass or in enamel-lined cans. On account of the high acidity, it is unsafe to use plain tin.

The fruit should be picked when it is beginning to turn soft. If too ripe, it will cook down to a jam in the can and if too green will be too sour and lacking flavor.

Wash the fruit and grade into Extra Fancy, Fancy and Pie grades, the grading being made on appearance, size and degree of ripeness. The prime ripe, large fruit of unblemished appearance should comprise the Extra Fancy grade; the medium-sized sound and prime ripe fruit, the Fancy grade; and the soft, small and blemished fruit, the Pie grade. Fill the cans full and cover the Extra Fancy grade with a hot 50 per cent syrup, the Fancy grade with hot 40 per cent syrup, and the Pie stock with hot water. Cap, tip and sterilize at 212° F. for eight minutes in No. 2 or No. 3 cans if the fruit is soft; if firm, cook 12 minutes. Gallon cans must be cooked twenty-five minutes because of their larger size. Chill the cans in cold water after cooking.

If sterilized in glass, proceed as for apricots, except that the plums are not pitted before placing in the jars. The Green Gage and Egg plums are the varieties most used.

Prunes.—Prunes are not canned commercially, but are perhaps preferable to dried prunes for home use. Select well colored ripe prunes of large size. Wash and place in cans. Cover with a hot 40 per cent syrup. Cap and tip. Process at 212° F. for twelve minutes for No. 2 or No. 3 cans. Chill in cold water after sterilizing.

In jars they are covered with a 40 per cent syrup at 212° F. and sterilized by placing in water at 175° F.; heating to 212° F. and boiling for twenty minutes in the usual way as described for apricots.

Cherries.—Cherries canned without pitting develop a "bitter almond" or "pit" flavor, pleasing to some and disagreeable to others, although the pitted cherries are probably most in demand. Small hand-pitting machines can be obtained from any hardware store for a small price. All pitting machines remove the pits by means of a cross-shaped plunger which lacerates the flesh more or less, and therefore the fruit must be canned immediately after pitting to check spoiling by fermentation. The Royal Anne, a large white cherry, is seldom pitted. Cherries tend to shrivel in heavy syrups or if covered with hot syrups, Only moderately sweet syrups should be used therefore and the cans exhausted by heating before sealing, rather than by adding hot syrup.

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Grade the cherries into extra fancy, fancy, and pie grades. Wash thoroughly in cold water. Pit if desired. Fill into cans or jars and add a cold 40 per cent syrup to the extra fancy grade; a 30 per cent to the fancy, and water to the pie stock. Cap. Exhaust cans in water at 150° F. for fifteen to twenty minutes (see p. 15) and tip the ventholes. Sterilize No. 2½ or No. 3 cans in boiling water or steam at 212° F. for eighteen to twenty minutes; No. 2 cans, fifteen minutes; and gallon cans for thirty minutes. Sterilize jars as directed for apples for thirty to thirty-five minutes at 212° F.

Blackberries.—Sort into three grades, making an extra fancy grade of the largest prime ripe fruit, fancy of medium-sized firm fruit, and a pie grade of the soft, small, or under-ripe fruit. Wash and fill into enamel-lined cans or glass jars. Fill the extra fancy cans or jars with cold syrup of 60° Balling, the fancy with 50 per cent syrup, and the pie grade with hot water. See pages 15, 16 for preparation and testing of syrups. Hot syrups should not be used, as they will cause shriveling.

Cap the cans and exhaust by placing in boiling hot water for five minutes. Remove and tip the ventholes and return to the boiling water. No. 2½ or No. 3 cans are kept for twelve minutes at the boiling point of water; No. 2 cans, eight minutes; and No. 10 (gallon), twenty-five minutes. Chill the cans in cold water after cooking.

Jars should be cooked for thirty minutes at 212° F. as directed for apples.

Alternative Method for Blackberries.—Blackberries shrink during cooking and the fruit which fills a can when fresh will shrink to about two-thirds after sterilizing. If the cans are to be well filled, the blackberries must first be cooked slowly in the syrup for fifteen minutes, so that the shrinkage will take place before canning.

The fruit is then filled into the cans or jars hot, and after sealing, sterilized for only five minutes at 212° F. Jars require ten minutes. The extra syrup formed by the juice of the fruit can be used on the next lot or the excess moisture may be boiled off and the fruit made into a preserve before canning.

Loganberries.—Loganberries may be canned in practically the same way as recommended for strawberries. Lacquered cans or glass jars must be used.

Raspberries.—Raspberries shrink very greatly on cooking, so that a can filled with the fresh berries, sealed and sterilized, will show a considerable loss in volume of solid fruit on opening. To avoid this shrinkage in the can, the fruit must be cooked before the cans are filled.

Sort out defective berries and wash. Transfer to a kettle and add an equal volume of sugar. Cook slowly until the fruit has reached the desired consistency. If the syrup is tested at this point by a saccharometer it should test about 50° to 55° Balling. Fill into cans or jars hot. Cap and tip. Sterilize at 212° F.; five minutes for cans and ten minutes for jars.

If there is no objection to shrinkage of volume in the can, the berries may be covered with a hot 50 per cent syrup and sterilized for ten minutes at 212° F. for No. 2 or No. 3 cans, or for twenty minutes for glass jars.

If the berries are to be used only for pies, they may be filled into cans with hot water and No. 2 or No. 3 cans sterilized at 212° F. for ten minutes and gallon cans twenty minutes.

Strawberries.—These berries shrink very badly in volume if cooked in the can.

Grade the berries into extra fancy and pie grades. Stem and wash thoroughly. Place the extra fancy berries in the kettle and add an equal volume of sugar.

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Cook down slowly until the syrup will test 50° to 55° Balling. Drain off excess syrup and fill into cans hot. Can, tip and sterilize at 212° F. for five minutes for No. 2 or No. 3 cans. Glass jars may be filled hot and sterilized in boiling water for ten minutes.

The pie grade can be placed in cans, covered with hot water and sterilized for ten minutes at 212° F. for No. 2 or No. 3 cans or twenty minutes for gallon cans.

Currants, Cranberries, Gooseberries.—These fruits are used only for pies, jellies, and jams, and are not commonly canned. They may be put up in enameled cans or in jars in plain water and sterilized at 212° F. No syrup need be used, as it will be found more satisfactory to add the desired sugar when using the fruit later for pies, etc.

The fruit should be washed, placed in cans or jars, which are then filled with boiling water, sealed and sterilized at 212° F. for fifteen minutes. Jars should be filled with hot water at about 212° F. and sterilized at 212° for twenty-five minutes, as directed for apricots, pages 22 and 23.

Grapes.—Muscat grapes are canned commercially in considerable quantities in California and are used chiefly for pies. Thoroughly ripe Muscats are removed from the stems and graded for size and appearance. Only two grades need be made, the large unblemished berries for the extra fancy and the small and imperfect berries for the pie grade.

Fill the cans to the top and add a hot 40 per cent syrup to the extra fancy and plain hot water to the pie fruit. Cap and tip in the usual way. Cook No. 2½ or No. 3 cans for ten minutes at 212° F. and smaller cans for eight minutes in boiling water.

The fruit may be packed in quart or pint jars and sterilized in the usual way for twenty minutes at 212° F.

Figs.—Figs are usually put in glass in the form of preserves. The fruit should be allowed to ripen thoroughly on the tree and must be handled carefully during picking and transferring to the cannery.

In commercial manufacture of fig preserves, the fruit is peeled by a dip of hot lye, followed by washing under a vigorous spray of water, in the same way as with peaches (see p. 22). They are then placed in steam-jacketed kettles with an equal weight of sugar, boiled down to a preserve, packed hot in glass and sealed without further sterilization.

For home use, ripe figs may be used without peeling. After cutting the stems, the fruit is weighed and placed in a preserve kettle or stewpan. For each pound of fruit, one pound of sugar is added and enough water to prevent scorching. Boil down slowly until the hot syrup will test 60° Balling or 33° Baumé, or until the mixture reaches a boiling point 8° above the boiling point of water, which is for most localities 220° F., or until the fruit is well cooked and of a consistency of a heavy preserve. Jars, with their caps and rubbers, are sterilized by heating in boiling water. They are then filled with the boiling hot preserve and the caps screwed down at once. As soon as filled the jars should be placed on their sides and turned occasionally during cooling to insure that the whole interior of the jar is sterilized with the hot fruit. Fruit preserves will not ferment if the sugar content is high enough, but may mold if the jars and contents are not thoroughly sterilized.

Smyrna figs have a thicker skin than the Mission, and therefore are better if peeled before cooking. If thoroughly ripe, this may be done by hand, but it adds greatly to the labor and expense of preparation.

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Rhubarb.—From a culinary point of view, rhubarb is a fruit and is very easily sterilized and canned in the same general way as other fruits. Since it is used chiefly as a pie stock no sugar need be used.

Wash the stalks; cut into short lengths and fill into enamel-lined cans or glass jars. Cover with hot water and seal. Sterilize cans twelve minutes at 212° F. and jars twenty minutes at 212° F. The rhubarb shrinks during sterilization, and in order to get a fuller can or jar it should be boiled a few minutes before canning.

Plain tin cans are soon badly corroded by rhubarb and preferably only glass should be used.

Pineapple.—Canned pineapples can be bought at such a moderate price that it will not pay to buy fresh fruit in the California markets for canning.

Oranges.—Oranges must be sterilized in a heavy syrup and at a moderate temperature to be palatable. The fruit must be ripe or almost over-ripe in order that it will not turn bitter.

Thoroughly ripe, sweet oranges are peeled, cut into slices of about half an inch in thickness and placed in enamel-lined cans or glass jars. They are then covered with a 60 per cent syrup, heated to 150° F. and then cans or jars sealed. After sealing these are completely immersed in water at 150° F., which is gradually heated to 175° F. Cans are kept at this temperature for fifteen minutes and jars for twenty minutes. Remove and allow to cool; do not cool in cold water.

Fruit prepared in this way will for a time be delicious, but will gradually deteriorate in flavor after three or four months.

Ripe Olives.—The canning of ripe olives for market would require a more extended discussion than could be given here. The following method of pickling and canning is suited for home use, particularly for the Mission and Manzanillo varieties.

Select large, ripe, well-colored fruit. Prepare a lye solution consisting of four ounces of lye to each gallon of water. Treat the olives with this in earthenware crocks and leave until the lye has well penetrated through the skin. This can be determined by cutting an olive open and is shown by a discoloration of the flesh beneath the skin. Drain off the lye into another container and leave the olives exposed to the air for twenty-four hours. This is to darken the color, and they should be stirred seven or eight times during the process.

Dilute the lye solution already used with one gallon of water to each three gallons of lye and replace on the olives. Stir often and watch the treatment until the lye reaches the pit. Then remove and expose the olives to the air again for eight hours. Cover with water changed twice daily until all taste of lye or bitterness is removed. Make up a salt brine of four ounces of salt to the gallon of water. Place the olives in this for three days. If the brine darkens after the first day change it for fresh brine of the same strength.

Place the olives in cans. Fill with boiling brine of four ounces of salt to the gallon of water. Cap and tip. Heat No. 2, No. 2½, and No. 3 cans for thirty minutes at 212° F. and gallons for forty minutes. Quart or pint jars require thirty-five minutes at 212° F.

If prepared for market, the olives should be graded for size and uniformity of color before canning.

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D. SPECIAL DIRECTIONS FOR VARIOUS VEGETABLES

Most vegetables have only a small amount of acid as compared with fruits. This low degree of acidity, as we have seen, permits the growth of certain bacteria which are very difficult to kill by heating. Vegetables therefore are hard to sterilize. Tomatoes, which resemble fruit in respect to their acidity, are an exception.

Usually in sterilizing vegetables temperatures above 212° F. are necessary, or three repeated sterilizations at 212° F. This requires either the use of a

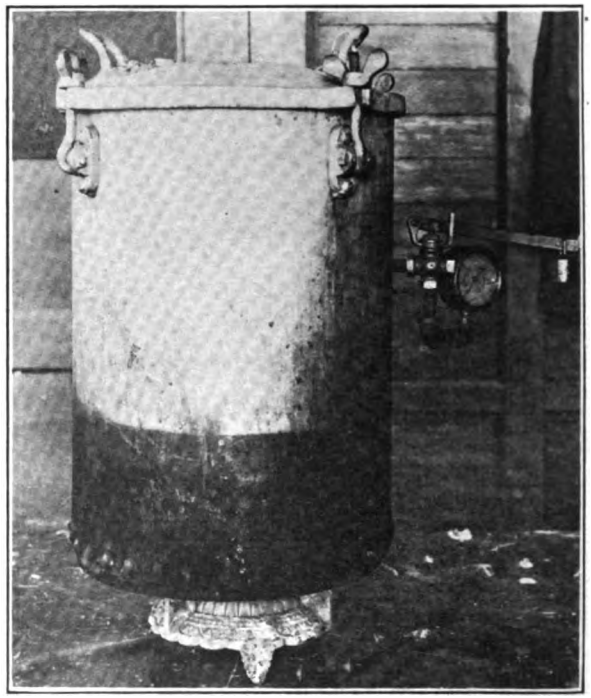

Fig. 10.—A type of steam pressure sterilizer.

steam-pressure cooker or the extra trouble of making three practical sterilizations. Steam-pressure cookers are not difficult to operate and can be obtained at prices as low as ten dollars (see p. 17). Fractional sterilization is accomplished by heating to 212° F. for forty-five minutes on each of three successive days (see p. 4). A single heating of three hours is not always successful.

The new method described on page 4 avoids both the expense of a pressure cooker and the trouble of repeated heatings, and can be highly recommended at least for home use. It consists essentially of making the vegetables slightly acid, thus rendering them as easy to sterilize as fruits.

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Artichokes.—Young artichokes only are used. The hard tip is trimmed off and some of the outer bracts removed, leaving only the tender parts. With wide-mouthed jars the trimmed artichokes may be canned whole; with solder-top cans the artichokes must be cut into vertical sections.

They are blanched for five minutes in boiling water (see p. 14), placed in cans or jars and covered with hot 2 per cent brine. They are then capped and tipped immediately and sterilized in a steam cooker at 239° F., or ten pounds pressure. No. 2 and No. 3 cans require twenty minutes and jars thirty. Jars must be filled with boiling hot brine, with precautions against breaking, and sealed immediately before being placed in the cooker. After heating for the required time the cooker must be allowed to cool until the pressure falls to 0 before opening.

Where a steam cooker is not available, three heatings of one hour each to 212° on three successive days may be used (see p. 4). With the method described on page 4, in a brine of 2 per cent acidified with one-fourth of a pint of lemon juice per gallon, a single heating for forty-five minutes for cans and one hour for jars at 212° F. is sufficient.

Asparagus.—Grade into large, medium, and small sizes. Commercial canners make five sizes, but such close grading is not necessary in home canning. Cut into lengths to fit the container. This is conveniently done by making a small box the depth of the can or jar and open at the top and one side. The bud ends of the stalks are placed in the box against the closed end and the butts protrude from the open end. They may be cut off flush with the edges of the open side of the box with a large sharp knife.

Blanch the stalks in boiling water for about one minute for small stalks and two or four minutes for the larger sizes. Pack into jars or cans with the tips up. No. 2 tall square cans are most commonly used. Cover with hot 2 per cent brine and seal. Sterilize No. 2 tall cans fourteen minutes and jars twenty after ten pounds pressure (239° F.) is reached. Chill the cans in cold water. If jars are used the sterilizer must be allowed to cool to 0 pounds pressure before opening, since the jars will explode when the pressure is quickly released.

By use of lemon juice (see p. 4) forty-five minutes for cans and one hour for jars at 212° F. is sufficient. Five ounces of lemon juice is added to each gallon of brine. Three fractional sterilizations of one hour at 212° F. for three successive days (see p. 4) can also be used.

Green Beans.—Green beans are best for canning when very young and tender; the larger and harder the pods and beans become, the lower their value for canning. Beans are usually put up in No. 2 cans.

Grade into a small tender size, grade No. 1, a medium size, grade No. 2, and a large size as grade No. 3.

Snip or string after grading. The two larger sizes should be broken into pieces about 1½ inches long, while the small or No. 1 grade may be canned whole.

Blanch the No. 1 grade two minutes in boiling water and the larger grades for four minutes. Chill in cold water and fill into cans or jars.

Cover with 2 per cent hot brine and seal. Sterilize No. 2 cans thirty minutes at ten pounds pressure (239° F.) and jars forty minutes at the same pressure.

Green beans can be successfully canned by fractional sterilization of one hour each (see p. 4) or in the lemon-juice method (see p. 4) in thirty-five minutes

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for cans and forty-five minutes for jars. In this method use one-fourth pint of lemon juice per gallon of brine.

Beets.—Beets should be small and turnip shaped if canned for market. The extra fancy grade may be 1 to 1½ inches in diameter and the fancy over 1½ inches.

Scald in boiling water or in steam until the skin will slip easily. Chill in cold water, peel, cut off the tops and fill into cans or jars. For market purposes jars are ordinarily used.

Prepare a brine containing 2 per cent sugar (or 2⅔ ounces per gallon) and 2½ per cent salt (3¼ ounces per gallon of water). Heat to boiling and fill cans. Cap and tip. Enamel-lined cans should be used.

Sterilize at eight pounds pressure, or 235° F., for thirty minutes for cans and forty minutes for jars. Chill the cans after cooking.

With the lemon-juice method heating to 212° F. for one hour for cans and one and one-half hours for jars is necessary. (See p. 4.)

Three fractional sterilizations for one hour each may also be used.

Carrots.—Carrots can be prepared for the can by washing, scraping and blanching four minutes in boiling water. Fill into cans and cover with hot brine consisting of 2 per cent salt and 3 per cent sugar; or with a sauce made to taste from salt, sugar, butter, and water. Seal. Sterilize at ten pounds pressure for thirty-five minutes. If four ounces of lemon juice is added to each gallon of brine the carrots may be sterilized at 212° F. for one hour or one and one-half hours in jars. If lemon juice is not used, one hour on each of three successive days will be needed. (See p. 4.)

Sweet Corn.—The ears are shucked, silked, and the corn is cut from the cob with a sharp knife. A syrup of one-half pound sugar and one and one-half ounces salt per gallon is made. The corn and a small amount of syrup (enough to cover the corn) are mixed and heated in a pot to boiling. The mixture is filled into cans or jars hot, sealed and sterilized for fifty minutes at fifteen pounds pressure or 250° F. Corn is very hard to sterilize. Cool the cans after sterilizing.

Corn can be sterilized at 212° F. for one and one-half hours if six ounces of lemon juice per gallon of syrup is used.

Peas.—Picking and hulling peas by hand is a very slow process and not to be recommended for commercial canning. Large canneries do the hulling, grading, blanching, and filling of cans entirely by machinery. It is feasible, however, to shell enough peas for canning for home use by hand.

Select as tender peas as possible and shell. Place in a wire basket or in a clean cloth and blanch in boiling water long enough to wrinkle the skin slightly. This will usually be about one to four minutes, depending upon the size and tenderness of the peas.

Fill into cans or jars and cover with a hot brine consisting of 2⅓ ounces salt and 3½ ounces of sugar per gallon and seal. Sterilize cans twenty-five minutes at 240° F. or ten pounds pressure, and jars forty minutes at the same temperature. Cool cans in cold water after sterilizing.

Sterilization of Peas at 212° F.—To the above brine add seven ounces of lemon juice per gallon; fill into containers hot and seal. Sterilize cans for forty-five minutes at 212° F. and jars sixty minutes. If lemon juice is not used, sterilize the cans or jars for one hour each day for three successive days.

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Peppers, Pimentos, and Chiles.—These vegetables are usually peeled by causing the skin to slip by roasting or immersing in hot lye solution or in hot oil. The methods are hardly applicable to household use. They have been peeled successfully in the laboratory by immersing from two to three minutes in a boiling lye consisting of 3 ounces soda lye and one gallon of water. They were then chilled at once in cold water and the skins came off easily from the large sweet peppers and pimentos. Small, pungent, tough-skinned Mexican peppers did not yield to this treatment. When peeled in this way, the peppers are obtained soft and pliable and can be folded into the cans after cutting off stems and removing the seed cores.

The peppers need not be peeled for home use and need only be stemmed and cored and heated in boiling water a few minutes to soften them so that they will pack into cans or jars satisfactorily.

Fill with boiling hot water and seal. Sterilize at 212° F. for eighteen minutes in cans and forty minutes in jars. Olive or salad oil may be used instead of water to fill the cans.

Pumpkin.—Cut open the pumpkin; scrape out pulp and seeds and cut the flesh and rind into strips. Boil in water until soft. Scrape the flesh from the rind and mash the pulp through a colander and heat almost to boiling temperature in a double boiler or in a steam retort to avoid scorching. Pack into cans or jars hot and seal. Sterilize cans one hour at 240° F. or ten pounds pressure and jars one and one-half hours at the same temperature.

The lemon-juice method can be used as follows:

Cut the fresh pumpkin into pieces to fit into cans or jars and fill containers with them. Prepare a brine containing 2⅔ ounces of salt per gallon and 4 ounces of lemon juice per gallon. Heat to boiling and fill the cans or jars of pumpkin with the hot brine. Seal. Sterilize cans at 212° F. for one hour and jars one and one-half hours. Pumpkin prepared in this way has kept perfectly and, although it comes from the can rather firm, it has a good flavor and appearance.

Tomatoes.—Tomatoes have a considerable amount of acid which checks growth of heat-resisting bacteria. They are therefore easily sterilized at 212° F.

For canning purposes, the variety used should be smooth and of a deep color. Corrugated tomatoes are too difficult to peel.

Sort the tomatoes and reject those which are spoiled and under-ripe. Place in blanching basket and immerse in boiling water long enough to crack and loosen the skin. This will usually be about one-half to one minute. Remove and chill in cold water. Slip off the skins and remove the cores. Heat to boiling in the juice obtained in coring. Pack tightly into cans or jars hot. Seal. Sterilize No. 3 cans for thirty minutes at 212° F. and No. 10 cans seventy-five minutes at 212° F. if packed hot.

If the tomatoes are packed without the addition of juice, it is known as a solid pack; if juice is added, a standard pack.

Tomatoes may be canned whole to be used for slicing for salads. Select small tomatoes that will go into the jars or cans. Cover with a hot tomato juice pressed from mashed fresh tomatoes. Seal. Sterilize cans twenty minutes at 212° F. and jars thirty minutes.

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1902. Report of the Agricultural Experiment Station for 1898–1901.
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CIRCULAR No. 159
JANUARY, 1917

AGRICULTURE IN THE IMPERIAL VALLEY

A MANUAL FOR SETTLERS[1]

BY WALTER E. PACKARD

SOILS

The character of the soils of this region varies so greatly that it is essential that any one buying farm land should pay particular attention to the soil conditions and should get soil that is adapted to the crops he expects to raise. One should not buy hard or medium hard land for vineyard planting, for example, for vines will not do their best on any but the sandier soils. These hard soils are better adapted for sorghums, barley, or cotton.

The soils of the Imperial Valley range from heavy clays to coarse sands and gravels. The most extensive types are clays, clay loams, silt loams, sandy loams, and fine sandy loams. Considerable areas of sand and gravel are found on the mesa lands and along the edge of the delta soils. Practically all of the soils in the valley except those of the mesas have a subsoil or substratum of heavy clay at depths varying from one to twenty feet. This impervious layer has a marked influence on the water and plant relations of the soil, and especially on the drainage conditions. The depth of the soil above the clay layer should be determined before deciding upon the crops to be grown or the methods of handling those crops.

[1] This Circular is published to give to both new and old settlers in southeastern California a summary of the facts so far gathered regarding the agricultural conditions and resources of this very interesting region. The information presented here has been gathered from many sources during five years of investigational work carried on in this section by the University of California. Some of the data were obtained through general observation and study, but most of them are the results of work carried on at the Imperial Valley Experiment Farm established at Meloland in 1912 for the purpose of continuing the investigations then started and for working on the numerous problems arising in this section.

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The clay soils are very compact and hard to handle. A representative sample showed a content of 28.78 per cent of colloidal clay and 63.31 per cent of fine silt. Water penetrates this soil very slowly, and on account of the difficulty of tilling and properly caring for the crops, lands of this type have not proven very productive. The clay loam, a medium heavy soil, is the predominant type. A representative sample contained 14.34 per cent of clay and 15.34 per cent of fine silt. This soil can be tilled without difficulty and is especially adapted to field crops. The sandy loams and fine sandy loam soils are adapted to

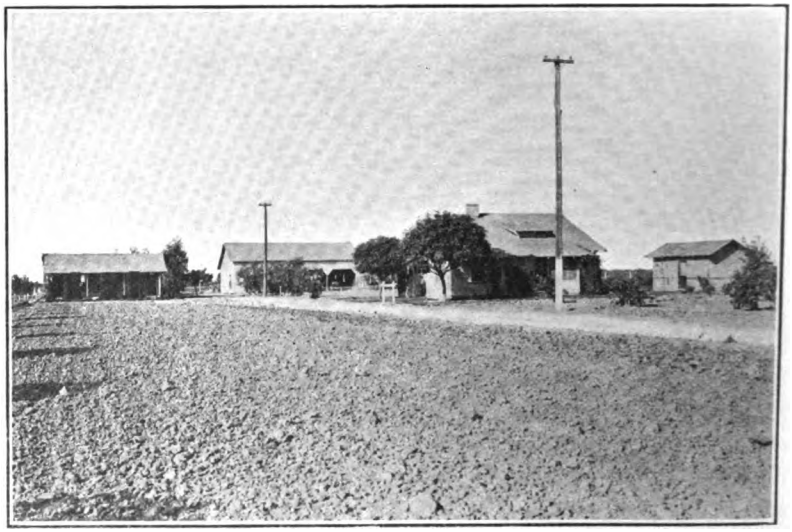

Fig. 1.—The Imperial Valley Experiment Farm, El Centro, Cal. The Imperial Valley Experiment Farm, consisting of forty acres and located in the central portion of the valley, was established in 1912 for the purpose of studying agricultural and horticultural problems in the irrigated valleys of Southeastern California.

alfalfa, truck farming or fruit growing. The sands, although very productive when rightly handled, are not so desirable as the sandy loams because of their porous nature, permitting rapid penetration of water, so that when the clay substratum is present at moderate depths there is danger of a high water table with its resultant evils.

The soils of the San Pasqual Valley are quite different from those of the Imperial Valley. The sandy types predominate. The character of the soil varies greatly on almost every farm, making uniform irrigation very difficult. The subsoil is a sand, which, allowing a very rapid movement of water, results in the formation of a high water table through seepage and excessive irrigation.

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The soils of the Palo Verde Valley resemble those of the Imperial quite closely in many respects, although the effect of soil material of local origin can be clearly seen. The heavier soils correspond to the clay loams of Imperial Valley, containing more sand, however, which gives them a more mellow appearance. The subsoil here is almost invariably a sand stratum, as found in the San Pasqual Valley.

The Coachella Valley soils are local in origin and differ greatly from the Colorado deposits. These soils are predominantly sandy and contain much mica. When properly handled they are very productive.

The major portion of the soils of this region are noted for their fertility. Not only are the essential plant food elements, potassium and phosphorus, present in sufficient quantities, as indicated in accompanying tables, but the amount of carbonate of lime present is such that these elements should become readily available. There is enough potash in the samples tested to render the soils permanently fertile in respect to that element. With the yearly addition of both potassium and phosphorus in the irrigation sediments the necessity of applying commercial fertilizers containing these elements may never arise. Nitrogen, which is lacking in all desert soils, is deficient and must be added by applications of manure, commercial fertilizers or by plowing under leguminous crops, such as alfalfa. Organic matter of any kind should be added at every opportunity, as the results in increased crops are very marked.

ANALYSES OF SIX TYPES OF SOIL COMMON IN THE GENERAL REGION OF COACHELLA AND IMPERIAL VALLEYS[2]

	Imperial Valley clay	Imperial silt	Imperial clay	Coachella Valley	El Centro	Sediment in irrigation water
Insoluble matter	43.81	62.67	38.65	57.53	51.68	31.36
Soluble silica	19.51	10.93	15.79	12.20	17.90	29.12
Potash (K_2O)	1.25	.74	.76	1.54	1.27	1.18
Soda (Na_2O)	.44	.29	.34	.64	.30	.57
Lime (CaO)	7.25	3.75	4.35	5.92	5.55	5.35
Magnesia (MgO)	2.37	1.68	1.24	3.23	2.28	1.89
Manganese br. ox. (Mn_3O_4)	.....	.01	.10	.01	.01	.03
Iron peroxid (Fe_2O_3)	4.37	3.71	6.15	5.63	3.96	5.26
Alumina (Al_2O_3)	10.45	4.26	10.52	7.52	9.05	13.92
Phosphoric acid (P_2O_5)	.16	.22	.23	.16	.14	.13
Sulphuric acid (SO_3)	.22	.36	.49	.37	.22	.....
Carbonic acid (CO_2)	.....	2.32	5.30	5.35	.....	10.82
Water and organic matter	9.76	9.93	15.84	5.35	7.78	
Humus	.24	.65	.38	.32	.30	.....
Humus nitrogen, per cent in humus	6.14	10.90	18.40	5.27	5.15	.....
Humus nitrogen, per cent in soil	.02	.....	.....	0.017	.017	.....

[2] Analyses by courtesy of Dr. C. B. Lipman, University of California.

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The proper physical condition of the soil must be established and maintained, as upon this depends not only the right penetration of air and water but also the promotion of necessary bacterial action, whereby both nitrogen and other plant foods are made available. Too much water rots the roots, prevents the development of nitrifying organisms, and aids the development of injurious bacteria. *Deep plowing, with the turning under of as much organic matter as possible, will do much toward improving the physical condition of the soils.* Blasting the harder types of soil before planting trees breaks up the stratification and aids root and water penetration, if the work is done when the soil is dry.

Fig. 2.—A road along the flood plain of the Colorado in the San Pasqual Valley.

Alkali is present in all of the soils, as is true of any arid region. Some soils contain enough to affect the most alkali-resistant crops. Some, on the other hand, do not contain enough to hurt the most sensitive plants, and most of the soils do not contain sufficient alkali to injure the common crops grown in the region. *No person should plan a permanent planting of trees until he knows definitely that neither the surface soil nor the immediate subsoil contain sufficient alkali to injure his planting.* This station makes examinations of soils for alkali for land owners.

Common salt, or sodium chloride, is the most common of the so-called alkali salts. Comparatively little black alkali (sodium carbonate) is found, possibly owing to the fact that the content of gypsum (calcium sulphate) is generally high in these soils. The common white

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alkali (sodium sulphate) forms a large proportion of the salts in some sections and is present in fairly large proportions in most instances.

There are different methods of handling alkali land which are more or less satisfactory. In the first place, alkali-resistant crops can be grown on the poorer soils. Date palms, for example, will grow in strong alkali and thrive in this region. For this reason much of the bad alkali land should and probably will ultimately be devoted to the production of dates. Bermuda grass forms good pasture on land unfit for less resistant crops. Cotton will grow in land where other field crops will not thrive.

Drainage is the most satisfactory way of reclaiming alkali land. When good drainage outlets, such as the Alamo or New River channels, are available, drains can be constructed to carry off the surplus water with much of the alkali. The reclamation work is very slow, however, and considerable time is required to free the soil from alkali. Flooding without under-drains tends to wash the salts down and not off. A shallow drain ditch at the lower end of the field to catch waste water will not carry away much alkali. Such a drain helps mainly in that it makes possible the longer running of water across the field. This fact is shown clearly in any irrigated land containing alkali and has been practically demonstrated in many cases. In spite of this fact, many hold to the idea that the salts are washed off from the surface in ordinary flooding.[3] Where a water table exists underdrainage must be practised.

Where a farm is being damaged by alkali and high water table in a section where these troubles are common there is little use for one man to attempt reclamation alone, as the expense would be too great. A drainage district should be organized and a co-operative drainage system put in for the whole section.

CLIMATIC CONDITIONS

As is the case with other inland arid regions, the weather of this section is noted for its extremes. It is characterized by changes and variations in temperature, wind velocity and humidity which are often very sudden. Being hemmed in by mountains on the east, north and west, the valleys are denied the great regulating influence of a large and deep body of water. Variations in temperature within every twenty-four hours are usually great, and sometimes amount to as much as 50 degrees. Throughout a large part of the year the relative

[3] For further information regarding alkali refer to Hilgard's "Soils," Macmillan Co., and Farmers' Bull. No. 446, U. S. Department of Agriculture.

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humidity of the atmosphere is very low, and consequently the days are relatively warmer and the nights relatively cooler than those of humid and coast regions in the same latitude. On account of the dry air and the consequent rapid evaporation of moisture from the body, the high temperatures of summer are not unbearable, and do not seem nearly so high as the dry-bulb thermometer would indicate. During a part of July and August, when the relative humidity is increased by the proximity of thunder storms, the weather is very unpleasant. During the winter months the weather is usually dry, crisp and sunny, and is considered by all to be both delightful and invigorating.

WATER SUPPLY

Except in the Coachella Valley, all of the water used for irrigation in this region comes from the Colorado River. A small amount of land could be reclaimed by developing the water of the San Felipe, Carrizo and other smaller creeks which drain a portion of the eastern slope of the Peninsula Range.

About 159 gaging stations have been maintained on the Colorado since 1890 and the general discharge characteristics fairly well determined. Accurate estimates of the possibilities of irrigation can not be made, however, until more is learned regarding the river flow, return seepage, duty of water and evaporation. The total acreage possible to irrigate has been variously estimated by engineers familiar with the river.[4, 5] The greatest use of water in this region fortunately comes during the flood stages of the river and the minimum during the low stages. Increased irrigation in the middle and lower drainage area of the Colorado will greatly decrease the minimum flow and make storage ultimately a necessity. The irrigation projects on the upper tributaries of the river use a considerable volume of water during the early summer months when water is plentiful and very little during the months of minimum flow. The return seepage from this irrigation will probably have an increasing effect on the minimum flow and prove a benefit rather than a harm to the irrigators of this section, provided the water used is not carried into other drainage channels.[6] Reports of unusual seepage from the irrigated lands along the Colorado have

[4] A very complete account by H. T. Cory of the break in the river with a full discussion of the engineering features connected with the close of the break and the construction of the irrigation system can be found in Vol. xxxiii, No. 9, of the Proceedings of the American Society of Civil Engineers.

[5] Report by C. R. Rockwood to Imperial Irrigation District, May, 1915.

[6] See "Seepage and Return Flow," by L. G. Carpenter, Bull. No. 180, Pt. 2, Colorado Agricultural College; also Kansas-Colorado suit, Direct Testimony of Louis G. Carpenter, The Smith-Brooks Printing Company, Denver, Col.

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been made, but no actual measurements reported. It is reasonable to assume, however, that return seepage affects the minimum flow of the river, as it does in other cases where this has been proved to be true.

By the development of storage reservoirs, for which there are numerous sites, the acreage that may be irrigated from the Colorado River could be greatly extended. The following table gives approximately the storage possibilities:

APPROXIMATE STORAGE POSSIBILITIES ON THE COLORADO RIVER AND ITS TRIBUTARIES[7]

Green River (including the Brown Park reservoir site)	3,000,000 acre ft.
Grand River (including the Cremmling reservoir site)	3,000,000
Little Colorado	50,000
Bill Williams Fork	100,000
San Juan	1,504,000
Virgin River	.....
Gila River	.....
Colorado below Mojave and above Yuma	.....
Total	10,154,000

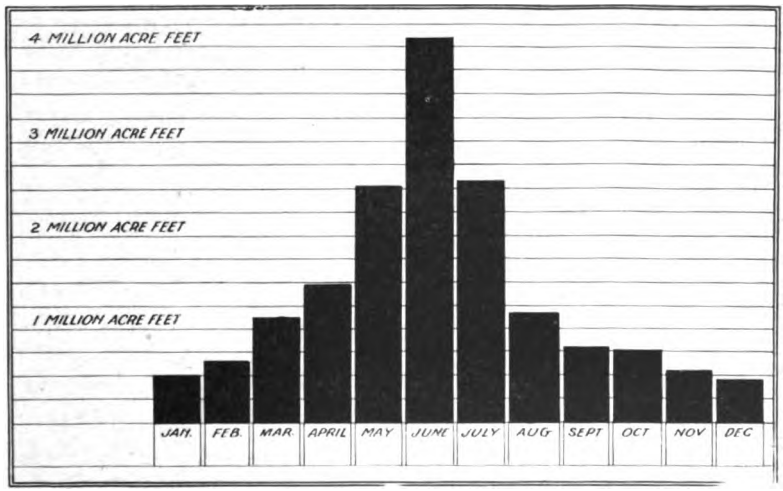

Fig. 3.—The yearly record of waterflow in the Colorado River shows greatest supply in June; percentage of silt content least during June.

All of the water used in the Coachella Valley comes from artesian wells. These wells vary from 100 to 550 feet in depth and deliver from nine to fifty inches. Many of the wells have an artesian flow to

[7] See report by H. T. Cory on "Irrigation and River Control" in Vol. XXXVIII, No. 9, of the Proceedings of the American Society of Civil Engineers.
"The Colorado River and its Utilization," by E. C. La Rue, Water Supply Paper 395.

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the surface, although in most cases pumps are used. The water is sometimes pumped directly into a reservoir, where it is stored until used for irrigation.

The source of the water supply for the Coachella Valley is the White Water River, which drains the eastern slopes of the San Bernardino Mountains. The run-off sinks into the open sands and gravel very rapidly, forming the underground storage supply. This supply is, of course, limited, although it has been carefully estimated that practically twice the present area can be irrigated from wells if the water is rightly handled and conserved.[8]

WATER FOR DOMESTIC SUPPLIES

Practically all of the domestic water used in the Imperial Valley comes directly from the irrigation canals. The water is run into large settling pools, from which it is pumped or baled by hand. Where the pools are so situated that they can be easily cleaned the water can be

Fig. 4.—A common method of securing a domestic water supply. Water is dipped into the tanks, where the silt is allowed to settle.

[8] Water Supply Paper, U. S. Geological Survey, No. 225, on "Ground Waters of the Indio Region," by Walter C. Mendenhall.

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kept clean and pure by frequent flushing out and refilling. As the Colorado River flows through a comparatively uninhabited territory for hundreds of miles, there is little chance that the water would carry any pathogenic organisms. The ditches are nearly all above the surface of the ground and therefore receive no contaminated seepage or sewage from local sources. Where ground water is used, sewage should always be disposed of through septic tanks, and not in cesspools. The water used for drinking is, of course, always filtered through a stone filter, both to get rid of the fine clay particles that remain suspended in the settled water and as an added precaution against infection.

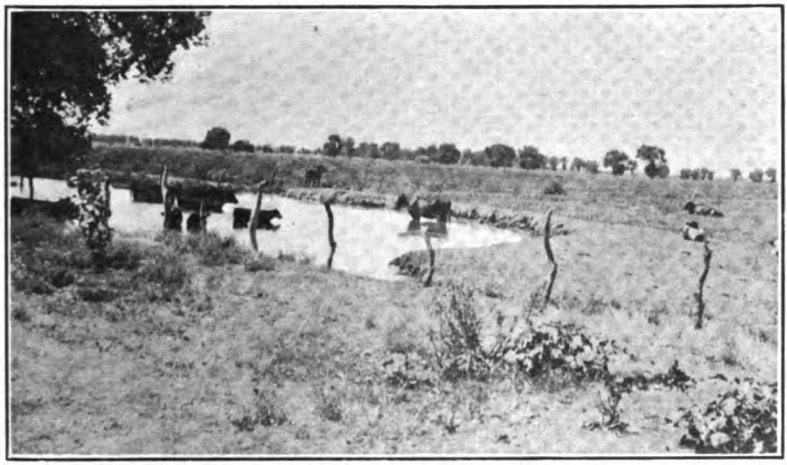

Fig. 5.—A common water hole for stock. Such places should be avoided and proper sanitary watering facilities installed.

The number of bacteria in water is reduced fully 50 per cent under ordinary conditions by filtering.

Attempts have been made to put down wells in various parts of the valley, but with the exception of the east side, around Holtville, no water of good quality has been struck. In certain cases, especially along the larger canals running through sandy soil, local wells can be dug and good water secured from the canal seepage.

In the Palo Verde and San Pasqual valleys the domestic water is secured from shallow wells, dug to seepage water. The artesian water of the Coachella Valley is, of course, used as domestic water in that section. It has been suggested that some of this water could be piped to Imperial Valley to furnish domestic water for the cities, and Colorado River water furnished to Coachella Valley for irrigation purposes.

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IRRIGATION

Irrigation is essential to the growth of any crop in this section. The rainfall, varying from one to five inches a year, does not usually add enough moisture at one time to sprout the seeds of the desert annuals and is of no value from an agricultural standpoint.

The irrigation of crops is the most important farm operation, for, other factors being equal, the productivity of a fertile soil is proportional, up to a certain point, to the amount of moisture present, provided there is no excess which would restrict the entrance of air to the roots. The water used by plants is from 200 to 1000 times their dry weight, and therefore the importance of sufficient moisture is clear. Alfalfa, for example, will wilt on the clay soils of this region with 15 per cent of moisture present, and, on the other hand, will grow on the sandy types with but six or seven per cent present. There must be present a surplus over the amount retained by the soils when plants wilt, in order to sustain plant growth. Many examples of insufficient irrigation occur, especially on hard soils, and in but few cases do the irrigators know anything about the amount of water added. *Too many are satisfied with a saturation of the soil surface without knowing anything about the penetration of the water. It is essential to know to what depth the moisture penetrates in order to irrigate intelligently.*

While irrigation is an all-important operation, it can be easily overdone. Plants may be drowned out as well as dried out, hence care must be taken not to allow an excess of water to collect. Too much water prevents the development of roots and limits the feeding zone just to the extent to which over-irrigation creates a saturated condition. *Over-irrigation in every region is too often practised,* resulting ultimately in the rise of ground water, which may ruin the soil unless expensive drainage systems are established and maintained. The Alamo and New River channels form an excellent natural drainage outlet for the Imperial Valley, but the existence of these channels must not create a feeling of safety which would result in carelessness in the use of water. This cannot be emphasized too much, for it is highly important that the people of this practically new district should profit by the experience of the many older sections that have been ruined by seepage and over-irrigation.

The number of irrigations and the length of each irrigation depend upon the character of the soil and the method of applying water. One irrigation per cutting will grow a good crop of alfalfa on sandy loam soils, when two irrigations on medium or heavy soils are required to

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get anything like a comparative yield. *Every farmer should know his soil conditions and irrigate in such a way that the moisture condition will be as perfect as possible.* The only way to know whether the water is penetrating deeply enough, or to know whether too much water is being applied, is to use an auger or sampling tube and note how far the water has penetrated.

The quality of irrigation water in Imperial differs from that in most streams of the arid west in the amount of silt carried in suspension throughout the year. The water is always muddy, carrying from 84 to 3263 parts in 100,000 parts of water.[9] Since the soil of a large

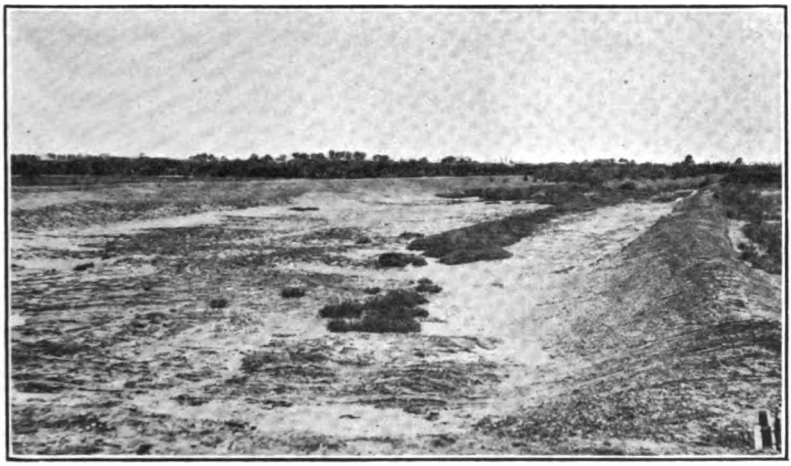

Fig. 6.—Lowland along the Colorado River which has received too much water, resulting in the rise of alkali.

part of this region is essentially an accumulation of this silt, the sediment which comes into the fields through the canals is a fertilizer, having the same general chemical properties as the soil, but being a little more finely divided, since the coarser particles are usually deposited in the ditches.

The chemical and physical properties of the sediments depend upon their source, and consequently vary in different seasons. The silt content varies greatly, but in general during the winter months the river is low and the silt content is also low, most of it coming from the Grand Cañon region. At times during the winter, especially during a rainy period in Arizona and Nevada, the silt content increases almost to its maximum. When the river rises in April from the effects of the melting snow at the headwaters of the Grand and Colorado

[9] Bulletin No. 44, Arizona Experiment Station.

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rivers the amount of silt increases slightly, most of it coming from erosion on the upper part of the river. As the spring floods subside the amount of silt often increases. The greatest quantities of silt are carried by the canals in the late summer during the rainy season in Arizona, which cause great freshets in the Virgin, Little Colorado, and Gila rivers. These silts give the greatest trouble to both water company and farmer.

All of the silts are rich in phosphoric acid and potash and some in nitrogen.[10] The soil washed from the great grazing stretches in Arizona during the early fall carries with it considerable organic

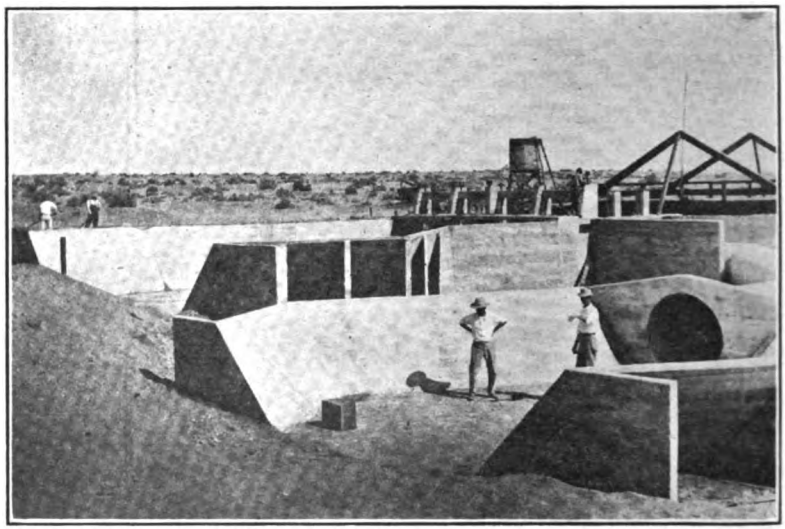

Fig. 7.—Concrete structures are rapidly replacing the wooden gates and shacks at first installed.

matter which is especially valuable as a fertilizer. Forbes has calculated from tests made of the Colorado River water at Yuma that if four acre-feet of water is used in irrigation .23 of an inch of soil would be added to the land.

Mechanically the silts are both good and bad, depending upon their origin. In general, however, they tend to lighten the heavy soils and to give body to the sandier types. The heavy silts or sands which roll along the bottom of the ditches are the source of much expense in maintenance charges and should be eliminated. Lighter silts which are normally carried on to the land are of great fertilizing value.

[10] Bulletin No. 41, Arizona Experiment Station.

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These silts will bear the same relation to the soils of this section as do the Nile sediments to Egyptian soils, or the silts of the Yang-tse-Kiang to the continued fertility of the delta soils in that region.[11] Wherever this condition exists in older countries, such as parts of China, Japan, and Egypt, the silt is utilized with the utmost care.[12]

From a mechanical standpoint the sediments are troublesome in the ditch and cause an annual expenditure of nearly a half million dollars in keeping the canals cleared out. The farm ditches are usually cleaned out by means of a V-shaped crowder, although occasionally it is well to let the ditch go dry and clean out the sediments with a team and Fresno scraper. Various types of dredgers and large Vs are used on the main canals. The ultimate disposal of this accumulation of silt is a serious problem. In lands where labor is cheap it is transported to the fields by hand labor. It is entirely possible that some machine, such as a modified manure spreader into which this silt could be dumped by the dredges, may be devised for moving the silt on to the land at a low cost.

The Colorado River water carries considerable quantities of salts in solution, the bicarbonate, sulphate and chloride predominating. The

RELATIVE AMOUNT OF SUBSTANCES IN SOLUTION IN WATER FROM COLORADO RIVER AT RAILROAD BRIDGE NEAR YUMA, ARIZONA[13]

Limiting dates of composite 1905	No. of daily samples	Dissolved solids (De) (Milligrams per liter)	Radicles in per cent of dissolved solids: Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + % K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chlorin (Cl)	Nitrate (NO_3)
Jan. 1–31	24	994	11	3.5	18	0.00	23	27	24	0.13
Feb. 2–28	20	816	11	3.2	21	.00	32	21	24	.04
Mar. 1–Apr. 2	33	686	10	2.9	20	1.9	36	20	22	.05
Apr. 3–May 1	27	609	11	3.0	19	1.4	38	22	19	.04
May 2–31	30	488	14	3.3	16	.00	43	25	14	.06
June 1–30	30	345	16	3.8	13	.00	50	26	11	.26
July 1–Aug. 1	18	395	....	3.5	11	.00	....	23	15	.28
Aug. 4–30	27	532	14	....	15	.00	....	30	16	.10
Aug. 31–Sept. 29	25	930	15	3.7	13	.00	....	33	15	.03
Sept. 30–Nov. 2	29	972	13	3.1	16	.00	23	33	14	.....
Nov. 4–30	18	870	13	3.1	17	.00	25	31	19	.07
Dec. 1–30	23	848	11	2.8	18	.00	28	27	22	.03
Mean	....	707	13	3.3	16	.28	33	26	18	.10

[11] Bulletin No. 44, Arizona Experiment Station.

[12] "Farmers of Forty Centuries," by F. H. King-Mrs. F. H. King, Madison, Wis., 1911.

[13] From Water Supply Paper, No. 274, U. S. Geological Survey, "Some Stream Water of the Western United States," by Herman Stabler.

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nitrates, which are present in small amounts, have, of course, a certain fertilizing value. The nitrates are highest during July and August, when the heavy summer rains occur on the grazing areas of Arizona and southern Nevada, as they supply appreciable amounts of organic matter.

The methods of irrigation are essentially the same as in other sections. Crops such as alfalfa or barley are flooded in "checks" or "lands" from 40 to 60 feet wide and from one-eighth to one-half mile long. In sandy soil, as before suggested, the lands should be small. not more than one-eighth mile long, in order to make it possible to

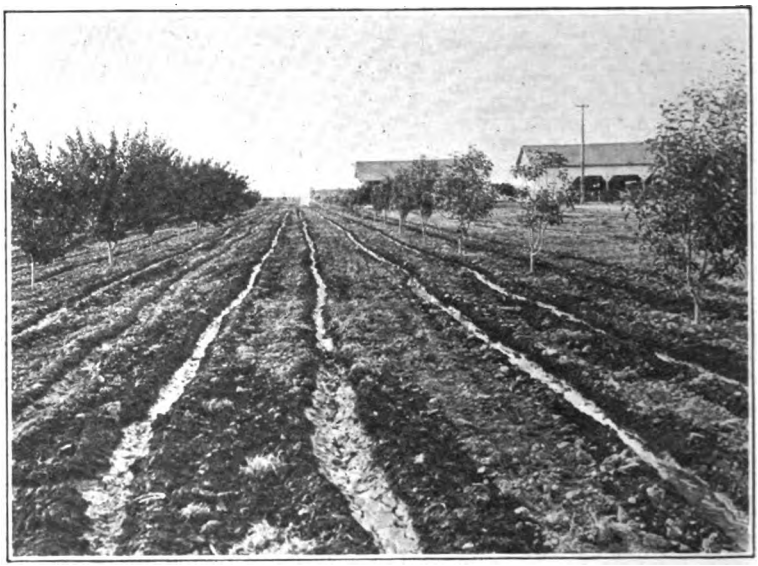

Fig. 8.—Small streams running for a long time in deep furrows will result in efficient irrigation on the clay loam soils.

irrigate rapidly without creating a water table. On hard or medium hard land the borders can be one-quarter mile long with no danger of over-irrigation.

Some are practising the method of corrugating alfalfa and barley fields, as is often done in Colorado and the northwest. Small furrows or corrugations are made from 2 to 3 feet apart in the fields by means of heavy runners or shovels attached to sleds. These small furrows direct the course of the water and tend to aid in an equal distribution. and also tend to prevent scalding, which is so common in fields flooded according to the usual methods.

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Such crops as cotton, corn, or cantaloupes are irrigated by means of furrows. In irrigating hard land in furrows, a very small stream run for a long time will often soak the soil to a much greater depth than by any other method. *The main point, when irrigating crops, is to know where the water is going and what it is doing, and this can only be determined by occasional borings. Knowledge of the soil and moisture conditions will enable a man to irrigate intelligently.*

ECONOMIC CONDITIONS

The size of the farm and the type of farming for the most successful operation in this section depend upon the capital available, the desires and capabilities of the individual, and the character of the soil. The farm should not be so small that an economical use cannot be made of the equipment. It is a mistake to attempt too small a plan to afford sufficient work for the stock and implements. Experienced men with small means may locate on small tracts (10 to 20 acres) of the best soil and make a living by a diversified and intensive system of farming, i.e., by the production of enough vegetables and fruits to supply the wants of the family as nearly as possible and by making something out of chickens, cows, bees, small fruits and vegetables. A man to succeed at this work must be careful in details, industrious and a good farmer. It is not possible to maintain the same standard of living on such a farm as on a larger farm with more capital invested. Usually farms where live stock or field crops are the principal sources of income require larger areas for equivalent labor incomes than those where fruits, vegetables or poultry are the main lines of production.[14]

In selecting a farm, the character of the soil is of prime importance, as success or absolute failure rests in the balance. "Soft" soil, free from alkali or water table, should be selected for intensive farming.

Farm land in this section with a water right can be purchased for from $50 to $300 per acre, depending upon the location, character of the soil, and improvements. The price of land is, however, not a dependable criterion of its value, and one who is buying land on which to make a home should take plenty of time to make sure that the soil conditions are satisfactory.

The price of farm labor varies from $35 to $50 a month, with board. Reliable and efficient men get, on the average, $45 and board, and day

[14] For a more complete discussion of the capital needed for successful farming refer to, "Some Things the Prospective Settler Should Know," Circular No. 121, University of California, Agricultural Experiment Station.

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laborers from $1.75 to $2.50 per nine-hour day. The majority of the farm labor is American. The negro is employed largely in the cotton fields, but not elsewhere to any extent. Hindus are occasionally employed by the month, but usually prefer to do contract labor, such as picking cotton or heading milo. Mexicans are employed to some extent on the larger ranches and do contract work, but are not usually employed by the month on the smaller farms. Japanese are important factors in the production of fruit and garden truck, especially cantaloupes. They usually work on contract, being seldom employed by the month by Americans. Laborers from southern Europe are becoming a more important factor, especially in the dairy and hog business.

The cost and supply of labor is such that the most satisfactory method of farming in this section is to handle only as much land as the owner can work or directly oversee, thus minimizing the necessity of employing much extra help.

FIELD CROPS

Adaptability.—Southeastern California is primarily a live-stock country and consequently a section where field crops predominate, as the cheap water, rich soil and a long growing season give this section a distinct advantage in the production of these crops. Cultural requirements can be so controlled, where intelligent practice is used, that large crops can be secured.

Crops.—Alfalfa is the predominating crop. It occupies practically all of the land at some time, as it is the basis of nearly all crop rotations. It forms the basis of the live-stock industry and acts as a soil builder and renovater.

Barley, wheat and milo furnish the principal grains raised, although some Indian corn and various varieties of non-saccharine sorghums are grown.

Cotton is an important crop of this section and has proven to be very well adapted to local conditions. Both long and short staple cottons are now grown, but it is probable that eventually some long staple variety will be grown to the exclusion of the short. Sugar cane has been tried and may prove to be adapted to the region and eventually develop into an important factor. Rice has been tried and may prove profitable for hard alkali soils where surface drainage is possible.

Berseem and buckwheat have proven unadapted to conditions and should not be planted.

In order to secure the largest yields of any of the field crops it is necessary to adopt some rotation scheme, as a one-crop system will endure but little longer here than in any other sections. If alfalfa is

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FIELD CROPS: THEIR ADAPTABILITY TO IMPERIAL VALLEY

Crop	Adaptability	Varieties recommended in order	Dates of planting	Dates of ripening	Average yield safe to figure on per acre	Length of time occupying land
Alfalfa	Very good	Chilian Peruvian Arabian	Sept. 30– May 1	Apr. 1– Oct. 30	6 tons in addition to winter pasture	All year
Barley	Very good	Common Beldi	Sept. 30– Feb. 1	Apr. 15– May 15	1500 lbs. to 2000 lbs. in addition to winter pasture	4–8 months
Broom corn	Good	Giant Dwarf	July 15– Aug. 15	Oct. 20– Nov. 20	400 lbs. to 500 lbs.	4–5 months
Buckwheat	Poor	Not recommended				
Clover[15]	Fair	White clover for lawn				
Corn (Maize)	Good	Mexican June Hickory King	July 15– Aug. 1	Nov. 1– Dec. 15	40 bu.	4–4½ months
Cotton	Very good	Durango Egyptian Mebane Triumph	Mar. 1– May 15	Aug. 15– Dec. 1	1 bale	All year
Cactus	Fair	Many varieties	Apr.–May Sept.–Oct.	All year	.....	All year

[15] Not recommended for field planting.

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FIELD CROPS: THEIR ADAPTABILITY TO IMPERIAL VALLEY—(*Continued*)

Crop	Adaptability	Varieties recommended in order	Dates of planting	Dates of ripening	Average yield safe to figure on per acre	Length of time occupying land
Flax	Fair	.....	Oct.	April	Has not been grown commercially	
		Sudan[16]	Apr.–July			
Grasses	Very good		June–Dec.		3 cuttings	7–8 months
Oats	Fair	Not recommended as grain crop	Oct.–Dec.	Apr.–May	No yield data available	5 months
Rice[17]	Fair	Honduras and Shinriki varieties	Mar.–July	June–Nov.	800 lbs. to 2000 lbs.	4 months
Sorghum	Very good	Milo Feterita Egyptian wheat or others	Apr.–Aug. 1	July–Dec.	2 crops in 1 yr., 1 ton per cutting	4–5 months for 1 crop 7–8 months for 2 crops
Sugar cane	Good	Varieties not tried	Mar.–Apr.	Nov.–Dec.	No data available	All year
Wheat	Very good	White Australian Chul Sonora Bob's Fretes	Oct.–Dec. 30	May	1500 lbs. to 2000 lbs.	5–6 months

[16] Makes good pasture on land not adapted for alfalfa.

[17] Data not complete. May prove valuable as reclamation crop on hard land.

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used as a basis, a profitable rotation can be planned in such a way that the land will be in almost constant use. The practice of growing a green manure crop, such as cowpeas, should prove profitable in many cases, both in increasing the feed produced and in building up the soil.

ALFALFA

Adaptability.—There is no crop better suited to the climatic conditions in southeastern California than alfalfa. Originating in Persia and Arabia before the dawn of agricultural history, this "Best Fodder," as the Arabic name signifies, has been associated for thousands of years with the hot and arid countries bordering the Mediterranean, and therefore finds its native environment in the Colorado River region. It can be said to be the basis of successful agricultural practice, as it forms the foundation of nearly every local rotation scheme, furnishing a good money-making crop, and at the same time adding the nitrogen and humus which are lacking in these arid soils.

Yield.—Alfalfa grows well during eight months of the year, making comparatively little growth during the winter period. Cutting usually begins in April and ends in October, six cuttings being the average, although seven, eight, or nine can be obtained on the best soils with good treatment. The average yield is about three-fourths of a ton per cutting, making a total of four and a half to five tons per acre per year. This average includes the alfalfa grown on hard and medium hard land not particularly suited to the crop. On sandy loam soils the yield per cutting would average a ton, while a ton and a half per cutting is not at all uncommon, making a total of from six to ten tons per acre per season. In addition to the hay produced, the land furnishes good pasture during the winter season. Barley is usually seeded in the field after the last cutting to increase the winter pasture.

Market.—Hay production is not considered profitable as compared to dairying, hog raising or cattle feeding, and consequently most of the alfalfa is pastured, although some hay is always put up for winter feed. The alfalfa should be cut when about one-tenth in bloom in order to produce the best cow feed. For horses and mules it may be older. Early cutting is not only a good practice from the standpoint of hay production but is essential in combatting the alfalfa worm, as shown in the article on insect pests.

Hay is sold for from $4 to $9 in the stack, the average summer price being from $5 to $6, and the winter price from $7 to $10. All of the hay that is shipped goes to the Los Angeles market.

Alfalfa pasture will support from one cow on two acres to two cows per acre the year round, depending upon the soil and water

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conditions. Considerable trouble is occasioned by bloat, although losses do not generally occur from this cause when the cows are fed on hay before being turned out to pasture in the morning. After a frost it is well not to pasture at night or early in the morning, as the alfalfa is apt to be injured at that time.

Comparatively little alfalfa is cut for seed, although great success along this line has been secured in the Yuma Valley of Arizona. On the softer soils underlaid with water at from four to eight feet good seed could undoubtedly be secured, as failures reported are apparently

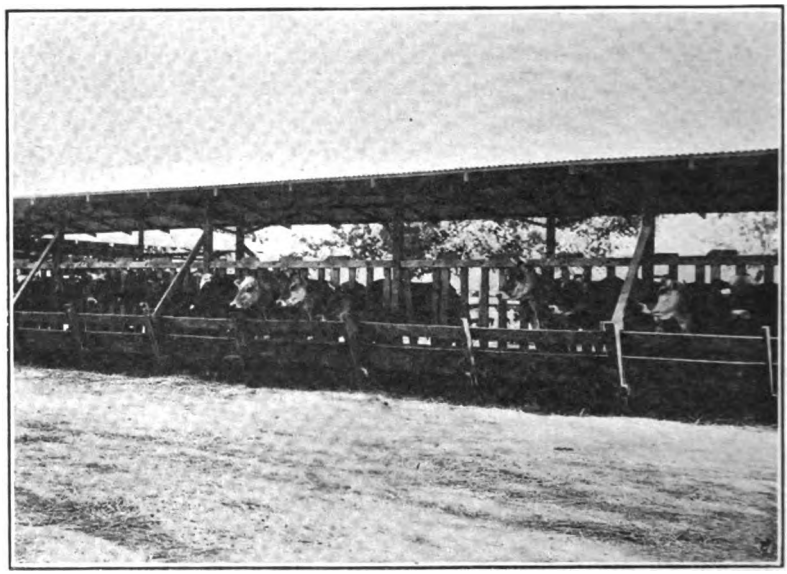

Fig 9.—The main market for alfalfa.

due to the fact that the water conditions were not favorable. The second cutting is usually utilized for seed.

Varieties.—The common (Chilean) alfalfa is at present the best variety to plant. It grows well, is hardy and stands heavy pasturing.

The Peruvian alfalfa, which is gaining much in favor in Arizona and elsewhere, is well adapted to conditions here and may soon prove to be the best variety for this section.

The Arabian alfalfa grows well, especially during the winter months, and makes an excellent hay, but is not hardy enough to stand pasturing.

Cultural Requirements.—Alfalfa succeeds on a wide range of soils, but will produce three times as much hay on some soils as on others,

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which indicates the necessity for care in selecting alfalfa land. The land should be plowed and well leveled before seeding alfalfa. Any irregularities in the surface are sure to result in a scalded patch with an ultimate introduction of Bermuda grass. The usual method of planting is to broadcast the seed after the land has been thoroughly irrigated, disced and harrowed. The land is then harrowed again and then irrigated. If a crust forms, another light irrigation is given in from three to five days to soften the surface and allow the seedlings to come through. No further irrigation is given until the plants have developed from three to four true leaves, as the silt will in many cases kill the stand by smothering the young plants.

Drilling in the seed is sometimes practiced, and with good results. There is some danger of getting the seed too deep, especially if the soil is at all loose. Drilling usually follows a thorough irrigation of the land as soon as the land becomes firm enough to disc and prepare a seed bed. The moisture in the soil will be sufficient to germinate the seed and sustain the plant until safely out of danger from damage by silt. If the seeding is not done when the soil is moist enough to sprout all of the seeds, the result will not be satisfactory, unless an irrigation is given before any of the young alfalfa plants that may have sprouted come up.

Alfalfa is usually seeded in October or in the early part of November. If planted in the spring, the young seedlings are apt to be killed by the blowing sands during the heavy winds, or by scalding in the intense heat of early summer. However, much alfalfa is started in the spring, even as late as May. The large percentage of silt carried by the irrigation water during the fall is the greatest objection to planting at that time.

Cultivation is usually practiced in the fall. The alfalfa is disced thoroughly after the last cutting. Twenty-five to thirty-five pounds of barley are usually sowed broadcast before discing, in order to increase the winter pasture.

Successful alfalfa culture in the Imperial Valley depends more upon the proper water conditions than upon any other factor. To produce a ton of dry hay the alfalfa plants must be supplied with from 400 to 800 tons of water. If this moisture is not available the yield will not be secured. *Not only must this moisture be present, but it must be present in an available form* (see article on irrigation). This means that from 4 to 8 inches in depth of water must be applied to the land to get one ton, correspondingly more than that to get a ton and a half to two tons. Lack of this available moisture is very often the cause of the poor yield frequently reported. This condition

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usually occurs on hard or medium hard land. This can be remedied by irrigating at least twice per cutting, with a comparatively small head run for a long time, which will give the moisture a good chance to go down. *The moisture condition should be watched and the irrigation practice adapted to the need.*

Careless irrigation often results in scalding out the alfalfa, leaving bare places which soon grow up to water grass or Bermuda grass. This condition exists especially at the lower ends of the fields. Drains at the lower ends of the fields are useful. *But when such drains exist, the tendency is to rely on them too much, with the result that irrigation is careless and much land scalded out.*

Insects and Diseases.—Alfalfa is seriously affected by the larva of the yellow alfalfa butterfly (*Colias eurytheme*) and by grasshoppers. *Euthrips Tritici* infests the blossoms of alfalfa, but does little damage. *Heliothrips facietus,* however, causes some damage to the leaves, giving them a mottled appearance. (For remedies see article on Insects.) No disease of consequence in this section is found on the alfalfa, although the alfalfa is affected by leaf spot and rust.

The Chalcid fly attacks from 10 per cent to 40 per cent of the seeds and causes a serious loss in the seed crop. The alfalfa weevil, which causes so much loss in Utah, is not present in this section.

BARLEY

Adaptability.—Barley is the principal grain crop of the valley. It is better adapted to a warm climate than any of the other small grains, although the hot weather rather than the cold is the limiting factor in its growth. It is grown for grain, for winter pasture and for hay, the usual practice being to pasture the fields in the fall and early winter and to let the barley go to hay or grain in the spring. In this way it forms a valuable green feed in the winter when the alfalfa is practically dormant. The barley ripens in April and May in plenty of time to prepare the land and plant corn or milo maize.

Varieties.—Common California barley is almost universally planted. Beldi, a new early variety of the six-row type, yields well and has the advantage of ripening from a week to ten days earlier than the common barley.

Market.—Barley is sold in the sack at from 85 cents to $1.50 per hundred f. o. b. local points. A good deal of the barley raised, however, is fed locally.

Yields.—Barley yields from 10 to 25 sacks per acre, 12 to 18 sacks being about an average under ordinarily good care.

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Soil and Cultural Requirements.—Barley is less sensitive than other grains to adverse soil conditions and does much better on a medium soil than on a loose sandy type. Barley is planted any time from September 15th to February 1st. From 30 to 35 pounds of seed is used for early planting and from 50 to 60 for later planting, when the barley is not so apt to stool heavily. The early sown barley is used as pasture and in January allowed to go to grain.

The seed is usually broadcasted on land previously irrigated, disced and harrowed. The seed is then harrowed in and the land irrigated. If the soil crusts, much of the seed is apt to be destroyed. Drilling in the seed on land still moist from previous irrigation gives excellent results, as a perfect stand is almost assured, if the soil is well soaked before planting. It is a good practice to drag the field with a broad drag after planting, to compact the earth about the seed.

Irrigation.—Barley is irrigated by flooding, the frequency of irrigation depending upon the character of the soil. The idea is to maintain a fairly even supply of moisture until ripening time, when the last irrigation is given.

Insects and Diseases.—The only insect pest of importance is the aphis. This attacks the young barley in February and in many cases totally destroys the crop. Barley planted early often escapes, when young succulent barley close at hand is destroyed.

Smut is found on some grain, but can be prevented by soaking the seed in a formaldehyde solution.

COTTON

Adaptability.—Cotton is adapted to the climate and soil conditions of this section. The early spring and long growing season, together with the fact that the moisture conditions can be almost entirely controlled, give ideal conditions for the production of maximum crops.

Imperial Valley grown cotton commands a premium over cotton grown in the South on account of the greater whiteness of fiber.

Varieties.—A big problem facing the cotton raisers of the valley is how to select and establish, to the exclusion of others, the variety that will bring the greatest net returns. It is highly important that one type be selected, as the growing of several varieties in one locality necessarily tends toward hybridization, the results of which are hard to overcome. This is especially true in this section, where the cotton plant is a perennial, the volunteer plants always being a source of crossing. As would be expected in starting a new industry, a large number of varieties of cotton have been tried. Out of the number three types remain.

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Long Staple.—A variety of cotton known as Durango is the only long staple variety grown. It is recommended as the best cotton to plant at the present time. The staple averages an inch and three-sixteenths to an inch and a quarter, and commands a premium of from 2 cents to 6 cents per pound over short staple. The ginning percentage averages 28 to 31 per cent. Durango yields as well as short cotton under similar circumstances and has a more upright growth and less foliage than Triumph, which allows the lower bolls a better chance to open and mature and makes picking somewhat easier. The irrigation of Durango is very important, for if not done well, there is a decided tendency to drop the squares on the least provocation.

A number of varieties of long staple cotton have been tried out, but in most cases have not proved a success. Improved long staple upland cotton from the south has been grown on a commercial scale, but has proved a failure on account of the small size of bolls and lack of uniformity in the staple.

Sea Island cotton has never been a successful crop here, although the plants do fairly well.

Egyptian cotton has proved to be well suited to local conditions and promises to become a profitable crop. The yields have been satisfactory, averaging approximately a bale to the acre when properly handled, while in individual cases a bale and a half to the acre has been grown. The staple averages 1 7/16 inches to 1⅝ inches and is very fine and strong. The first grade cotton sells for from 6 to 10 cents more per pound than short staple.

The ginning percentage of this cotton is rather low, averaging about 27 per cent. This, together with the cost of picking, which averages 2 cents per pound, as against three-quarters to 1¼ cents for short staple, has discouraged the growing of this type of cotton for the present. The comparatively high cost of picking is due to the fact that the bolls are rather small, and also to the fact that the cotton must be picked often and clean in order to get top prices for first-grade product. There is little doubt, however, but that this type of cotton will come into favor as the large tracts of land are divided up and it becomes necessary to make each acre count for the most. When this time comes this section will become noted for the production of this excellent cotton.

Short Staple.—Mebane Triumph is the only short staple cotton grown at present. This variety gives good results, as the bolls are fairly large, quite storm-resistant, and the ginning percentage is high. The cotton averages an inch in length and commands a premium over the short staple of the south, both for length and quality. The cotton is not injured by rains and is therefore white and clean.

Market.—The cotton produced in this section is sold at thirty points or $1.40 per bale off from New York quotations on account of freight. Most of the cotton produced is shipped to the South, although some goes to the Oakland Mills and to Japan.

Yield.—The average yield for this section is approximately a bale to the acre. Many have, of course, secured a much larger yield than the average. On good soils where water conditions are favorable it is safe to figure on one bale and a half to the acre.

Soil and Cultural Requirements.—Cotton is adapted to all but the very hard and the very sandy soils of this region. The plants resist

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a comparatively high percentage of alkali, when once well started, and will grow successfully on soil not suited to most other field crops.

Cotton is planted from the first of March to the first of June, April being the best month. The land is plowed and irrigated, then furrowed 3½ feet apart, and irrigated again. The land is then harrowed as soon as the soil is dry enough and the seed is drilled in on the ridge and when 6 inches to 10 inches high is thinned to 18 inches in the row. Egyptian cotton will yield better and the cotton will be easier to pick if planted 2 inches apart and thinned to 6 inches, as this tends to reduce the otherwise excessive vegetative growth. It is a common practice to irrigate again soon after planting to insure a good stand and give the young plants a good start.

Thorough cultivation should follow each irrigation. The land should be kept in as good a condition as possible, as irrigation without cultivation does not give the most satisfactory results.

Irrigation.—Cotton land should be thoroughly irrigated before planting. A comparatively light irrigation often follows planting to insure the germination of the seed and to give the young plants a good start. Water should then be withheld and the land well cultivated until after chopping or until the plants show a decided need. This forces good root development and starts the plant well. Irrigation should follow frequently enough to prevent the plant from suffering for water, but water should not be applied unless necessary. Too much water induces a rank vegetative growth at the expense of fruiting. This is especially true with a variety like Triumph, which has a naturally dense foliage that shades the lower parts of the plant when the first bolls are formed. Any sudden change from a dry to a wet soil will cause a serious loss of squares, especially in the Durango cotton. Thorough cultivation will do much toward equalizing the moisture conditions, provided the first irrigations are thorough.

Insects and Diseases.—This section is free from the boll weevil, so serious a pest in the South. The aphid has done more damage than any other insect. These insects attack the leaves and give the whole plant a gummy appearance. The plants are set back, but ultimately outgrow the aphis, and the real loss is not great, although some of the cotton is damaged by the honey dew.

Heliothrips attack the cotton occasionally, but are not serious pests.

The seed in the ground is often eaten by weevil, especially when planted early, where the ground is cold and the seed germinates slowly.

The cotton bolls are attacked occasionally by the boll worm, but the total damage is negligible. Boll rot and anthracnose are present and cause some loss, especially on over-irrigated rank grown cotton.

Bucculatrix thurberiella Busck. pierces the cotton leaves and is a more or less serious pest. Journal of Economic Entomology, vol. 9, no. 5, 1916.

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CORN (MAIZE OR INDIAN CORN)

Adaptability.—Field Corn. Mexican June and Hickory King are the only varieties of Indian corn so far tried in this section that have given satisfactory yields. These varieties do fairly well and may prove to be a real value for use in silos, to furnish succulent feed for winter when the pasture is short. The stalks grow to be 8–10 feet high and generally bear two ears to the stalk. Yields of 40–70 bushels are often obtained. The corn ear worm and the flea beetle are very serious pests.

Sweet Corn. The Mexican June corn is often sold for table use, and if picked at the right time is acceptable. Many varieties of sweet corn will grow if planted in the latter part of July, as recommended for field corn, but the ears are so badly injured by worms that a good crop is far from certain. Roasting ears are often secured in fifty days from planting.

Pop Corn. Pop corn does well, but the damage done by the corn ear worms makes successful production almost impossible. It is apparently well suited to local conditions if planted in the late summer so that it will be pollinated during the cooler days of early fall. The Pearl and Rice are both good varieties for this section.

SORGHUMS

Adaptability.—All varieties of sorghums do well in this section. Unlike Indian corn, the sorghums thrive during the hot weather. Two crops a year can be obtained by planting in the spring, harvesting in July, and then by irrigation a volunteer crop is brought on, in many cases outyielding the first one. The great objection to the sorghums is that they do not fit well in a rotation scheme. It is reported frequently that certain crops, such as barley or cotton, will not always do well following a crop like milo. The reason for this is not known, but the effect has been attributed to lack of moisture (not likely under irrigation), to poor physical condition of the soil and to a toxic effect of the roots. It is probable that the bad physical condition of the soil, especially where the land is not plowed, is the prime cause. The extent of this condition can not be stated, although it is certain that good crops have been secured after milo in numerous cases, and that milo has been grown in rotation with cotton and barley successfully.

Varieties.—Durras. The yellow or dwarf milo, white durra or Egyptian corn, the brown durra and feterita are the varieties most commonly planted. Milo stands second to barley in importance as a grain crop. This variety is popular on account of the dwarf characteristic, which makes harvesting less expensive. The seed is fairly well fixed in the head and does not scatter, and is not eaten by birds so badly as white durra, which scatters readily. Feterita is rapidly becoming a popular grain. It ripens from a week to ten days earlier than milo, has larger and softer grains, produces an erect head and requires little water, but so far has not yielded so well as milo.

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Kafir. The White, Red, and Black-hulled Kafirs are all grown to a limited extent. The crop is very good for fodder, much better in this respect than the durras. The fact that the stalks remain green longer after the grain is ripe gives this type an advantage for fodder.

Shallu or Egyptian Wheat. This sorghum has proved to be especially adapted to the poorer soils of the valley, doing better than other varieties on alkali land. The small grain makes excellent chicken feed and can be used to make flour for human consumption. The stalks are small and numerous and very tall. Heads are open and erect. Shallu has outyielded any sorghums so far tried at the Experiment Farm.

Sudan grass is a member of the sorghum family, and resembles Johnson grass in many particulars. It does not have the underground stolons, however, which make the Johnson grass so hard to eradicate. This grass can be cut from two to three times a year and will produce a large amount of feed. On account of its resemblance to Johnson grass, caution must be used in the purchase of seed. As a quick-growing summer hay crop Sudan grass has proved to be profitable and desirable.

Johnson Grass (Sorghum halepense). See article on weeds.

Sweet Sorghum. The sweet sorghums have been grown to quite an extent, but are not generally considered desirable because of the superiority of the durras and the Kafir corn, and because of the more lasting effect of the sweet sorghums on the soil and the difficulty of eradication.

Market.—A large part of the sorghum grain raised is fed locally. The milo has a feed value about 90 per cent of that of Indian corn. Milo sells for from $15 to $20 per ton in the head or from $20 to $28 threshed in a normal year.

Yield.—Milo yields from one-half to two and a half tons of heads to the acre. A ton is considered about an average yield. Other varieties, such as feterita or Egyptian corn, yield somewhat less.

Soil and Cultural Requirements.—The sorghums are apparently not so sensitive to soil conditions as many other field crops, and will do well on a variety of soil.

The seed is usually drilled in from 6 to 18 inches apart in rows 3 to 3½ feet apart on previously irrigated land. The land is usually irrigated again to bring up the seed, although a better stand is secured if the soil is well soaked before seeding and the land not flooded until the corn is well up. When planted on a ridge, irrigation after seeding insures an almost perfect stand, as the soil is not crusted above the seed as in the case of flooding.

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Insects and Diseases.—Sorghums are attacked by aphis and by flea-beetles when young, but if the land is well handled, so that the crop grows rapidly, they will outgrow these pests.

WHEAT

Wheat has been grown in the Imperial Valley for the past ten years, but has never assumed large proportions on account of the danger of rust, which at one time practically destroyed the wheat in the valley. It is also apparent that wheat is affected more by heat and is more sensitive to soil conditions than is barley. Outside of the one year referred to, when rust was prevalent over the entire state, rust has not been a serious factor and wheat grown on the Station Farm for the past three years has been entirely free from rust. The following varieties have yielded well and can be recommended for planting: Chul, White Australian, Bobs, Propo, Galgalos, Kubanka, King's Early, and Sonora. Of these Bobs wheat has given the best milling and baking test and is therefore the most profitable. It is difficult, however, to secure seed in commercial quantities, as this is a new importation from New South Wales and seed is not readily obtainable. The White Australian or common bluestem gave the most satisfactory test in the trials after Bobs. The wheat stood up well and yielded over 25 sacks to the acre. Wheat can be pastured like barley and is planted and irrigated in the same way. In order to produce a good milling wheat, it is well to hold the water off during the time of filling.

FIELD CROPS OF MINOR IMPORTANCE

The following field crops have been grown in Imperial Valley with more or less success, but plantings have never assumed commercial proportions. It is possible that some of them may be grown commercially in the future when more is learned regarding their cultural needs and when economic conditions warrant.

CLOVERS

As alfalfa takes the place of all clovers, except perhaps for lawns and cover crops, there is no particular reason for growing the clovers for other purposes. The intense dry heat of summer injures all the clovers which have been so far tried in the valley. Melilotus, which thrives here in the winter, may prove to be a valuable cover crop. White Clover, if given plenty of water, makes a fair lawn, but does not compare with lippia in value for this purpose. Burr Clover grows well during the winter, but does not make enough tonnage to warrant its use as a cover crop. Bitter Clover (*Melilotus indica*) makes a vigorous growth between early fall and late spring and is one of the best plants known for orchard cover crops and green manuring. It can be planted after cotton is picked in the fall and plowed under in April in time for spring planting. Such a practice is recommended, however, only where it is impracticable to grow alfalfa in a rotation.

GRASSES

Australian Rye Grass (*Lolium multiflorum*) is often used for a lawn grass, as it has a very attractive appearance during the winter months. This grass does not do well during the summer and requires constant irrigation to keep it

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alive, and for this reason is not so good as either lippia or Bermuda grass for this section. It can be sown in a Bermuda grass lawn for winter growth, thus keeping a green lawn the year round.

Bermuda Grass (*Cynodon dactylon*) is a pest when out of place, but a very good grass for certain purposes. There is no other grass in this section which gives such good results for a lawn. During the hot weather it does well and is not killed by neglect. For hard land, where deep-rooted plants do not do well, Bermuda makes a good growth and furnishes excellent pasture for horses, mules, sheep, or cattle.

Blue Grass (*Poa pratensis*) grows well during the winter season, but suffers in hot weather. If care is taken to keep the ground soaked it will live through the summer, but never does well.

Johnson Grass (*Sorghum halipense*). See article on weeds.

Millet (*Chaetochloa italica*). Most varieties of millet do fairly well in this section. Very little millet is planted, however, since other forage crops produce better results. It is generally sown during the latter part of the summer and harvested in the fall. Frost kills it about as readily as it does Indian corn. Pearl millet (*Penisetum spicatum*) can be grown successfully in the spring and will make a good growth during the spring and summer.

Orchard Grass (*Dactylis glomerata*) can be made to grow in the Imperial Valley, but it is not suited to the climate and its culture is not recommended.

Para Grass (*Panicum molle*) was introduced into the valley in 1909, and has made a remarkable growth in the few patches where it was planted. It is considered a bad weed in most tropical countries, although it is used as a pasture grass and for hay production. It propagates from the nodes of the stem, and consequently is hard to eradicate when once started on wet land, but in an irrigated section it can be dried out by withholding water and cultivating it down. It may prove to be a valuable plant for the hardest soils of the valley where alfalfa will not do well. It is a rapid grower and can be cut every six weeks or so during the summer time. While it is sensitive to cold, it will withstand any low temperature likely to occur in Imperial Valley.

SUDAN GRASS

(See Sorghums.)

OATS

Oats are not successful as a grain crop, but have been grown profitably as a winter hay crop. The plants make a big growth, but produce little grain. The Texas Red variety is most commonly planted.

RICE

Rice has been grown experimentally a number of times with a fair amount of success. It will endure the climatic conditions, if the proper water supply can be obtained. The plants will not thrive in water above 98 degrees, and it would be necessary to irrigate rapidly enough to keep the water moving well. The rapid deposits of silt where sufficient water is used would cause much trouble and expense. Water grass would tend to take possession of the fields, although this could be more easily controlled than in other sections on account of the fact that the weed seed can be sprouted by irrigation and later killed by discing before the rice is sown. It is probable that this crop will

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never be of commercial importance, although in Egypt rice is used as a reclamation crop, and it is possible that it may be valuable here for hard lands containing alkali. The rice could be grown while the land is being flooded for reclamation purposes.

FLAX

Flax has only been grown in a small experimental planting and very little is known as to its possibilities. It is well suited to the climate of the northern states and is quite sensitive to the summer heat and should be planted in October and harvested in the spring.

HEMP

The hemp plant (*Canabis sativa*) has been grown satisfactorily in this section, but no data are at hand regarding the yield secured. Whether hemp will prove to be a valuable crop depends largely upon the economic conditions.

SESBANIA

Colorado hemp (*Sesbania microcarpa*) is a water legume covering large areas in the Colorado delta. The conditions along the Colorado are usually favorable for this plant and almost impenetrable jungles of it cover large areas of delta land. It grows ten feet high or more and produces a large crop of well-filled pods. The roots are usually covered with large nodules, and it is possible that this plant may become a valuable cover crop. Many attempts have been made to utilize the strong fibers in the stem, but on account of the lack of effective decorticating machinery these attempts have failed.

OKRA

Okra does very well indeed in this section, producing large crops of good-sized pods.

SPINELESS CACTUS

Spineless cactus has been grown in this section for some years and when properly irrigated has yielded a large tonnage of slabs. There is little reason, however, for growing cactus in an irrigated country, as water must be applied as in the case of any other crop in order to secure a yield, and alfalfa under such conditions is more profitable. Cactus leaves have been successfully fed to cows in conjunction with hay and may prove to be good chicken feed for this section.

SUGAR CANE

Sugar cane has been tried experimentally and has proved to be well adapted to this section. The cane makes a very good growth and when properly handled should yield 20 to 40 tons to the acre.

Sugar cane is propagated from joints, about two tons being required to plant an acre. The joints are set about two feet apart in rows six feet apart and irrigated in furrows. The cane is harvested in November. No satisfactory variety tests have been made as yet, although the common purple cane has been grown satisfactorily.

The commercial success of sugar cane depends upon the establishment of raw sugar mills and a sugar refinery.

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VETCH

Common vetch (*Vicia sativa*) has been tried in the valley with variable results. Some report success and others failure. As the plant is killed by very hot weather it should be grown during the winter, being planted in October or the early part of November. Much experimentation is yet to be done with this plant. If it can be made to grow it will be a valuable addition to the list of winter leguminous cover crops for orchards.

BROAD WINDSOR BEAN

The Broad Windsor bean (*Fava vulgaris*) or horse bean, as it is sometimes called, does well as a winter crop. It was not affected by temperature as low as 24 degrees and yielded a heavy crop. The beans are rather thick coated and have a strong taste, but are relished by many people.

HORTICULTURAL CROPS

Crop	Adaptability	Varieties recommended	Dates of planting	Date of ripening
Almond	Good, but not recommended until further tried	I X L Nonpareil Jordon	Jan.–Feb.	July–Aug.
Apple	Poor	Gravenstein White Winter Pearmain	Jan.–Feb.	June 15–Dec.
Apricot	Very good	Newcastle Royal Blenheim	Jan.–Feb.	May 1–June 10
Avocado	Poor	Not recommended		
Banana	Poor	Not recommended		
Blackberry	Good	Crandall's Early California Everbearing	Jan.–Feb.	May–June
Cassava	Very good		Feb.–Mar.	June–July
Cherry	Poor	Not recommended		
Citron	Poor	Not recommended		
Currant	Poor	Not recommended		
Date	Excellent	Deglet Noor Hayani Thoory Menakhir Taziza'oot	Mar.–June	Aug. 1–Dec. 1
Dewberry	Very good	Gardena	Jan.–Feb.	May 1–20
Fig	Very good	Smyrna Class Brown Turkey Black San Pedro	Jan.–Feb.	May–Oct.
Gooseberry	Poor	Not recommended		
Grape	Very good	Sultanina (Thompson) Malaga Persian, Nos. 21, 23, 26	Jan.–Feb.	June 15–July 15

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HORTICULTURAL CROPS—(*Continued*)

Crop	Adaptability	Varieties recommended	Dates of planting	Date of ripening
Guava	Poor	Not recommended		
Jujube	Very good	Zyziphus Jujube Any variety	Jan.–Feb.	Sept.–Nov.
Kumquat	Good for home use	Marumi	Jan.–Feb.	Several crops per year
Lemons	Good	Eureka Lisbon	Oct.–Mar.	Mar.–June Sept.–Nov.
Lime	Uncertain	*		
Loquat	Fair		Jan.–Feb.	May–June
Mulberry	Very good	Black Spanish Black Russian New American	Jan.–Feb.	
Olives	Excellent	Mission Manzanillo Sevillano	Jan.–Feb.	Nov.–Dec.
Orange	Good	Washington Navel Navelencia Thompson	Nov.–May	Nov. 1–Jan. 30
Peach	Fair	Jap. Saucer Waldo Alexander Honey	Jan.–Feb.	June–Aug.
Peanut	Good	Virginia Red Jumbo Tennessee White	Mar.–May	Sept.–Dec.
Pear	Good	Winter Bartlett Winter Nellis	Jan.–Feb.	Aug.–Dec.
Pecan	Good	Not tried sufficiently to recommend		
Persimmon (Japanese)	Good	Tane Nashi Hashia	Jan.–Feb.	Oct.–Nov.
Pineapple	Poor	Not recommended		
Plum	Good	Mariana Satsuma Red June	Jan.–Feb.	May–June
Prune	Poor	Not recommended		
Pomegranate	Very good	Wonderful Spanish Ruby	Jan.–Feb.	Sept.–Nov.
Pomelo (Grapefruit)	Very good	Marsh Seedless	Jan.–May	Nov.–Dec.
Quince	Good	Orange Champion Smyrna	Jan.–Feb.	Sept.–Dec.
Raspberry	Poor	Not recommended		
Roselle	Very good		Jan.–Feb.	Oct.–Nov.
Strawberry	Good	Klondike	Nov.–Feb.	Feb.–May December
Walnut	Fair	Not recommended commercially		

* Not recommended commercially until further tried.

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FRUITS

Although a large variety of fruit can be successfully grown, climatic and soil conditions favor the production of certain kinds which have special adaptability or the advantage of earliness, and which, therefore, command good prices because of lack of competition. Many fruits can and should be grown for home use that would not pay in a commercial planting.

The recommendations given under the heading of soils and irrigation are of great importance in successful fruit culture and should be carefully considered.

The growing of summer cover crops will undoubtedly become a common practice. The intense radiation of heat from the light-colored soils has a bad effect upon the trees, in many cases undoubtedly causing a dropping of young fruit. Summer cover crops tend to reduce the temperature of the soil, to prevent the radiation of light and heat back upon the trees, and add the much needed organic matter. They grow at a time when water is plentiful and when cultivation of the orchard, which would otherwise be necessary, is expensive.

The fruits named below are especially adapted to the general conditions and are recommended for commercial planting under the particular conditions given in each case.

APRICOTS

Adaptability.—Of all deciduous fruits probably none is more at home in this section than the apricot. The crisp winters and hot, dry summers seem to be conditions needed by this fruit. All varieties ripen from a week to ten days earlier than corresponding varieties in other sections, which is a distinct advantage. It is true, however, that the yield, in most cases, is not quite up to expectations and the quality so far has not been equal to that of the apricots produced in other sections. For this reason, the Newcastle, which comes on to the market before apricots from any other section, is the most profitable variety. The Royal and Blenheim are satisfactory varieties, but as they come into competition with the early Newcastles from other sections it is a question whether they should be planted on a commercial scale. The Hemskirk, Moorpark, and Tilton have not given good results and should not be planted, at least until further experience indicates new and more successful methods of handling. Apricots on apricot roots are satisfactory, but plum roots are more resistant to wet soil and are not so subject to sour-sap.

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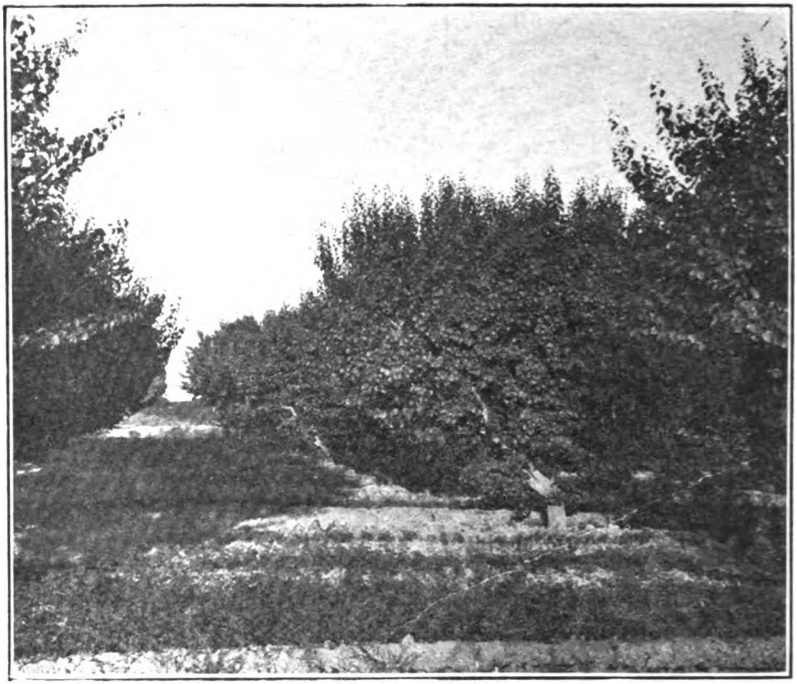

Fig. 10.—A well cared for apricot orchard in Imperial Valley which has paid well.

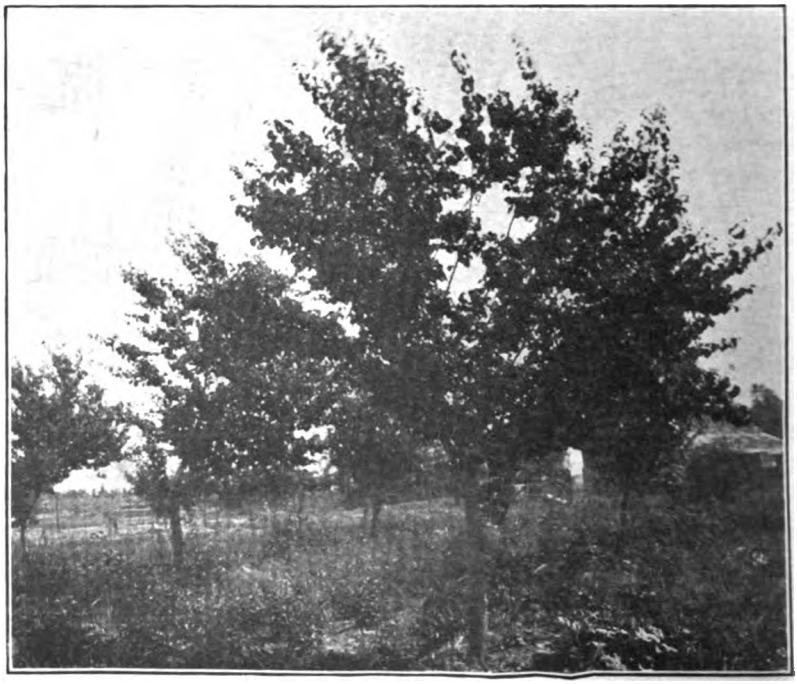

Fig. 11.—Neglected trees which are neither a success as a commercial venture nor as a home orchard.

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The trees are usually set 24 feet apart and pruned comparatively low to avoid sunburn. Thinning the fruit in the early spring will help to increase the size and the quality of the apricots produced. Sowing a summer cover crop will prove valuable. Apricot trees should not be irrigated for too long a time during the hot days of summer, as many trees are thus killed, a condition known as sour-sap often developing. Water should not be allowed to come too close to the trunks of the trees, as scalding at the surface of the ground is very common. It is well to stir the soil about the young trees frequently to prevent a crusting of the surface and an accumulation of alkali.

Market.—Most of the apricots shipped at present go to the Los Angeles market, where the bulk of the crop is sold before strong competition starts from other sections.

Insects and Diseases.—Crown gall is the most serious disease of apricots in this section. Sour-sap, resulting from over-irrigation during the summer months, must be guarded against. Root rot, also resulting from over-irrigation, is common. There are no insects of any economic importance, although San Jose scale has been reported in one instance.

DATES

Adaptability.—Coming from the oases of northern Africa and from the Persian Gulf region, the date finds its natural environment in this desert region.

Varieties.—Over two hundred varieties of dates have been imported from north Africa and the Persian Gulf region, many of which have produced crops. Many of the varieties are very promising, while others are rather inferior or not suited to the conditions. One point stands out prominently, however, and that is that no one variety is superior in all sections.

The Deglet Noor, for example, finds congenial conditions in parts of the Coachella and Imperial valleys, but in sections of lower total heat units and of high humidity, as in Tempe, Arizona, and in parts of the above named valleys, it is not always successful in ripening its crop on the trees. The proximity of large alfalfa fields, for example, will so affect the humidity in a locality that certain sensitive varieties suffer. More has to be learned regarding the climatic conditions of the date-growing sections of the old world from which the various varieties come and regarding the climatic conditions of general localities in this country in order to make intelligent plantings and avoid mistakes such as have been made in the past.

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The following varieties are perhaps the most promising among the dates so far tried, although they are suited to various conditions: Deglet Noor, Hayani, Saidi, Yatimeh, Taziza'oot, Thoori, Asharasi, Maktum, Menakhir.

There is a greater opportunity for the development of superior varieties of date palms from seed than there is with other kinds of fruit, such as grapes, apples, or olives, for example. Grown by the Arabs, the palms have not been scientifically selected, the present varieties being the product of chance. Scientific selection by a study of the vegetative characters, which are very distinct for the different varieties, will no doubt develop better varieties than any on the market at present. Every one interested in the culture of dates should plant

Fig. 12.—A good practice to follow in a young date garden. Onions planted between rows as a cash crop, while dates are reaching bearing age.

as many seedlings as possible with the idea of selecting the few superior palms that may appear, and from them develop varieties of special merit. The larger the number of seedlings planted the greater the chances of getting a really superior date. No one should plant seedlings, however, with the idea of developing a commercial date planting, as but a small proportion will be of value.

The large number of miscellaneous dates produced will soon spoil the market unless great care is exercised in the selection and standardization of the fruit shipped. This should be controlled by a date growers' association, such as the one now organized in both the Coachella and Imperial valleys.

Varieties differ greatly, of course, in size, shape, color, taste, sugar content and consistency. In some cases each date must be picked off

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separately and ripened artificially; others can be shaken from the bunch, practically ripening at once; still others must be packed and sold as a quickly perishable product. Dry or bread dates can be produced at a very low cost and sold at a profit for a very few cents, while others, such as the Deglet Noor, demand more time and care in the production and must be sold as a confection.

Cultural Requirements.—As the proverb goes, the date palm wants its feet in the water and its head in the fire. The tree does well on a large variety of soils, but seems to be most at home on the sandier types. Although alkali is not necessary or desirable for the successful growth of date palms, the plants will stand large quantities of alkali and will grow well when the total salts do not exceed 2 per cent. However, on account of its high potentialities, it deserves to be planted on the best land.

Dates are usually set 30 feet apart each way, which allows some crops to be grown between the young palms. In Africa citrus trees, apricots, figs and vegetables are grown in the shade of the large palms.

Date palms are not so sensitive to excessive irrigation as most other plants. The soil about the bases of palms may be submerged for months at a time without the trees being injured. Too little water, however, will stunt the growth and lessen the yield.

Insects and Diseases.—The Parlatoria and Marlott scales have caused much trouble to the early importers. Fumigation has not proved successful in eradicating these insects, but careful quarantine is now exercised to prevent their spread through new importations. Much experiment work is being done to find a means of exterminating the scale, and, if successful, the date industry will not be subject to the enormous annual tax that the citrus industry now pays for fumigation.

The injury done at ripening time can be successfully prevented by cheesecloth coverings over the date bunches. Fumigation at the time of packing is essential with some varieties in order to prevent damage by weevils and their larvae. The souring of dates has been the source of much loss, especially in the shipments of fresh dates, but it appears that this can be successfully handled by better methods of curing and packing and by handling soft, delicate varieties like any other fresh fruit.

POMELO (GRAPEFRUIT)

Adaptability.—The Pomelo, or grapefruit, has perhaps greater possibilities than any other citrus fruit in this section. The trees grow vigorously and bear heavy crops. The quality of the fruit is

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excellent and on account of its earliness has a distinct advantage in California markets over fruit from other sections. Green fruit can be picked from the trees and relished, as the required sugar-acid ratio is reached before the fruit is colored. At present, quarantine measures prevent outside grapefruit from being brought into California.

Particular attention should be paid to the remarks on soils given elsewhere in this bulletin before locating a citrus orchard, for many mistakes can thus be avoided.

Young trees should not be exposed to the hot sun when being transplanted and the trunks should be protected from the sun until the trees are large enough to give ample shade. The soil immediately about the trunk should be thoroughly mulched with straw or hay to prevent baking or the formation of an alkali crust and to aid growth. Water should be applied often, the frequency depending upon the type of soil and subsoil. Water should not be allowed to come in contact with the bark of the tree, but should be run in furrows long enough to soak the ground well. The Florida Sour stock has given the greatest satisfaction, although Trifoliata is being used considerably.

The Marsh's Seedless is the only variety grown commercially in the valley. Some of the earlier but smaller varieties may prove profitable. Only trees from well selected stock should be grown.

Insects and Diseases.—Citrus trees have not yet become infested with scale in Imperial Valley, and it is probable that the extensive fumigation carried on in the citrus belt will not be necessary in this region. Gum disease is a serious factor, but by proper care can be successfully handled. Mottled-leaf is not uncommon.

OLIVES

Adaptability.—The olive, a native of the hot, dry country of northern Africa, is a very promising fruit, standing second only to the date in its adaptability to the climatic conditions of southeastern California. It ripens in the fall when labor is plentiful and the climate delightful.

The records of the yields of the few olive trees now growing in this section are meager, but from the data at hand it appears that good varieties, such as the Mission or Manzanillo, would bear regularly and well. Several trees so far have not borne good crops, but it is the opinion of the writer that good yields will be secured in well cared for groves, unless an unusual dry spell coincides with the time of ripening. Along the lower river bottom, especially in the Palo Verde Valley, it is a question whether or not any but the Mission would thrive on account of the heavy frosts.

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Varieties.—The standard, broad-leaved or San Diego Mission is undoubtedly the best olive for general purposes. The buds or cuttings from which young trees are started should be selected from trees of known merit, as many Mission trees are inferior.

The Manzanillo is a good olive for pickling. It is larger than the Mission, but tends to ripen all at once, thus making the harvest more difficult.

The Sevillano is a large olive known commercially as the "Queen" olive. It is very attractive, but is somewhat coarse in texture, is clingstone and does not have the good flavor of the Mission.

The Ascolano is also a large variety of much promise.

Varieties highly satisfactory for olive oil making are Mission, Correggiola, Pendulina, Razza, and Nevadillo.

In transplanting young trees from the nursery to the field great care should be taken to prevent sunburn of the trunk at the surface of the ground and to prevent drying of the roots. The young trees are very tender and require good care. It is a good practice to place a deep mulch of dry straw around each tree to stop the radiation of the heat from the hot soil, and to keep the surface of the soil from crusting about the trunks of the trees. The careful treatment of the young trees will be well repaid, as the loss is often great when the work is carelessly done.

Olives require less water for successful growth than most trees, but to produce a profitable crop the trees must receive more water than simply enough to keep them alive. Olive trees do not do well on ditch banks where the roots stand in water.

Insects and Diseases.—Olive trees grown in this section are free from black scale, which hampers the industry on the coast. Olive trees are therefore clean and healthy and require no expensive spraying. Sunburn of the fruit has been reported, but has caused no serious loss, especially when the trees have been well taken care of.

ORANGES

Adaptability.—The dry air and bright sunshine of this section has a distinct advantage in the production of the Navel orange, since the fruit sweetens earlier and gives a deeper red color than is secured on the coast. This marked advantage is not possessed by the Valencia, however, and it is doubtful whether the culture of this variety would be sufficiently profitable to warrant commercial planting. The Navel orange ripens before damage may be expected from frost, which is another advantage in its favor. The fact that the Washington navel bears a comparatively light crop in sections where high summer temperature and very dry air exist is a rather serious drawback to the industry, and will undoubtedly have an influence on the acreage planted. The Navelencia has borne well

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in some cases and may prove to be valuable commercially. Many other varieties, however, may be grown in gardens for home use, such as Sweet Seedlings, Valencia, Mediterranean Sweet, Paper Rind, St. Michael, Ruby Blood and others.

FIGS

Adaptability.—Figs grow luxuriantly and bear heavily in this section. In the Coachella and Imperial valleys fig raising should develop into a very profitable industry, but the advisability of planting figs on the lower lands along the Colorado River is questioned because of the danger of frost.

Cultural Requirements.—Figs can be successfully grown with comparatively little pruning and cultivation. They will stand more water than most trees, which makes them desirable for planting on ditch banks.

Varieties.—Accurate data on the comparative value of the common varieties are very meagre. The Black Mission, White Adriatic, and Black San Pedro are known to produce well wherever they receive sufficient water and a reasonable amount of care.

The Smyrna class of figs do very well and will probably develop into a crop of considerable importance. The Smyrna, unlike other figs, must be artificially pollinated (caprificated) to produce a crop. Successful introductions of the Blastophaga (fig wasps) have been made and much advance made in this industry, especially by Mr. Francis Heiny of Brawley, who has been able to produce three crops of Smyrna figs in a season. This variety is especially good for drying.

Yield.—Fig trees bear three crops a year, the second crop being the main one. Trees but a year old will bear some figs, but they do not come into heavy bearing until four or five years old.

Market.—The market for fresh figs is limited by the difficulty of getting the product to market in good shape. Express shipments of caprified Smyrnas packed in chests of cracked ice have been made as far as Boston with good results, but the future possibilities are unknown. Fresh figs are safely shipped to the Los Angeles market. The market for dried figs is good, although little developed. The industry will, of course, have to face competition with the old world product.

Insects and Diseases.—The figs are quite free from injurious insect pests and diseases. Some figs are injured by birds and wasps, but usually not unless bruised. The "Fig eater" (*Allorhina mutabilis*) of Arizona, the large green beetle, which is so destructive in the Salt River Valley, has not yet entered California.

GRAPES

There are strong reasons for believing that the growing of early table grapes will be one of the most profitable industries in this section.

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Vines grow with remarkable rapidity and vigor and the fruit ripens before that of any other region.

Many vineyards have been dug up as unprofitable and others yield less profit than was expected. Many reasons are given, but the main

Figs. 13 and 14.—The way a vineyard should and should not be cared for. (1) A profitable vineyard. Vines pruned high with plenty of fruiting wood. (2)Low-pruned vines where grapes lie on the ground. A large proportion of the crop has to be thrown away.

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causes of failure seem to be planting in hard, unsuitable soil and failure to use suitable cultural methods.

Over two hundred varieties have been tried in the Imperial and Coachella valleys, but not over a dozen have shown much promise.

Varieties.—The Malaga is the most common variety. It ripens late in June to early in July. It ships well and brings from $1.25 to $2.50 per crate. The yield has not been heavy.

The Sultanina (Thompson's Seedless) is a favorite with many. The fruit is small, seedless, of pleasing amber color and good quality. It ripens about two weeks before the Malaga and brings from $2 to $3.50 per crate. The vines bear well when trellised.

The Persian varieties 21, 23 and 26 are attracting attention. They are earlier than the Sultanina and nearly as large as the Malaga. They have an attractive, rich, amber color and loose bunches which are easy to pack and ship well. They have brought from $2.50 to $4.50 per crate. The crops have been small, but their great vigor indicates that trellising and long pruning may increase their fruitfulness.

The Chavushi is a large, elongated grape of pleasing flavor, almost as early as 21. It is recommended for home planting.

The Hutab and Rish Baba are similar Persian varieties, ripening a little earlier than the Malaga. They are of striking appearance but poor shippers.

The Muscat of Alexander, Muscat Albadians, and Black Monukka are good or promising varieties.

The Cornichon is a large, elongated grape of fair shipping qualities, ripening two weeks later than the Malaga. It is a good grape for a late fall crop in a home planting.

Soil and Cultural Treatment.—Only soft, sandy soil is suitable. Cuttings are planted during the last part of February or the first part of March, preferably in the nursery, to be transplanted to the vineyard a year later. The young vines should be staked and carefully looked after. Owing to the vigor of the vines, the pruning should be relatively long. When this results in an exceptionally large crop the bunches should be thinned to increase the proportion of fine clusters.

Market.—The grapes are shipped to all parts of the United States. Prices vary with the season and the variety. The earlier shipments bring from $2 to $3 or more per box. In many cases the grapes are sold on the vines at from $30 to $40 per ton, the grower agreeing to haul them in lug boxes to the cars.

Irrigation.—The irrigation of the vineyard is one of the most important operations, but one that as yet is not clearly understood. Various systems have been tried, such as heavy winter irrigation with no spring irrigation, or light irrigations every two or three or four weeks during the growing period, and even up to picking time. From moisture determinations made in a number of vineyards irrigated at different times it seems that the number and time of

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irrigations is a more or less minor detail which has to be worked out by each farmer for his individual type of soil, the important point being to supply a liberal amount of moisture during the whole growing season. On some soils this can be done by heavy winter irrigations, while on the harder types, including even some sandy loam soils, water must be added at intervals during the spring, even up to within three or four weeks of picking time. Too little water seems to have as much to do with the formation of "water berries" as too much. A sudden change of moisture conditions during the sugaring period caused by an irrigation at that time apparently causes a water growth, and such a condition should be avoided.

Insects and Diseases.—The grape leaf hopper is a pest in this section, although most of the grapes are shipped before the bunches are much damaged. The hoppers give the leaves a mottled appearance by August and causes a good many to drop, which no doubt weakens the vines.

Thrips are found in large numbers on the blossoms, but cause no apparent damage.

Phylloxera has never gained a foothold in this section and will probably never be a problem on account of the strict quarantine on vine cuttings from the phylloxera section of the state.

It may be necessary in some seasons to treat the vineyard with sulfur for odium or powdery mildew which occasionally occurs.

Water berries are soft bluish grapes which occur frequently on vines receiving improper care, especially on young vines. They must be culled out, as they do not ship well.

FRUITS OF MINOR IMPORTANCE

The following fruits are well adapted to conditions, but have no special commercial advantage. Some may be grown commercially at a profit, while all can be successfully grown in a home orchard.

PEAR

Adaptability.—Among the fruits of secondary importance the pear stands first. Pear trees make a very healthy and normal growth and bear heavily in certain cases. The climate, however, is not adapted to the production of pears of the best quality; the flavor and aroma of a northern-grown pear seem to be lacking.

Varieties.—The Chinese pears, including LeConte, Kieffer, and Garber, succeed well when cross-pollinated. They bloom early and set well. The Winter Nellis has proved to be more generally satisfactory than any other shipping pear in the Colorado and Salt River valleys in Arizona. The Winter Bartlett is also one of the most promising varieties, and is the only variety which has been planted commercially in the valley. It ripens in the late fall. The fruit is apparently of good texture, but is apt to be rough and unattractive. The summer Bartlett, the great pear of commerce, does fairly well and will serve for home planting. The Kieffer is a large attractive variety, ripening about the same time as the summer Bartlett, but its quality is very poor. The Madeline and Clapp's Favorite are summer varieties, too soft for shipment but very desirable for home use.

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Soil and Cultural Requirements.—Pear trees can be treated much like other deciduous trees. Care must be taken to prevent sunburn and the trees should receive a plentiful supply of water.

Yield.—In general, the pear trees receiving good treatment in the valley have borne well. The blossoms are seldom killed by spring frosts and the trees bear early and are full of fruit wherever the proper varieties have been planted together to insure cross-pollination. It is probable that the suitable varieties will yield satisfactory crops.

Market.—The market for the early varieties will probably be limited, as direct competition will have to be met. Winter Bartlett pears will have to compete with the summer Bartletts produced in such localities as the Antelope Valley or Tehachapi, but as they ripen for Thanksgiving and Christmas markets prices will probably be good.

Insects and Diseases.—The pear blight, which has caused so much loss in other pear-growing sections, has not been reported as yet, although it may appear at any time. A peculiar knot appears on many pear trees, but apparently causes no serious trouble. The knot appears on the limbs at the joints and probably starts in a bud injured perhaps by some insect.

ALMONDS

Adaptability.—Although in general the climate of this section is well adapted to almonds, as the cool winters, followed by warm, sunny and dry weather at blooming and setting time, seem to supply just what is needed for the best bearing of almonds, commercial plantings should not be attempted until more is learned regarding the requirements of the trees in this section. Some trees in Imperial and Coachella valleys have borne well, but many of the trees are almost barren and have yielded little up to the present time. Almond trees make a splendid growth and may ultimately prove profitable, although at present commercial plantings would not be a safe investment.

The trees are handled as recommended for apricots. The Nonpareil is a good variety, but in planting it is necessary to plant one tree in four of Drake Seedling or Texas Prolific for pollination purposes. The Jordon almond is also recommended.

APPLE

The climate of this section is not well suited to the growing of apples. The high summer temperature, dry air and low altitude make it very unlikely that apples will ever be grown on anything like a commercial scale; in fact, it is a question if it is profitable to grow apples even in a home garden when good apples can be purchased cheaply. Only a few varieties bear well, and these are likely to fail early on account of sunburn, root rot and other troubles. The Bismark, Red Astrachan, Gravenstein, Black Ben Davis, and White Winter Pearmain do fairly well for home plantings.

BLACKBERRIES

Some varieties of blackberries grow thriftily and produce very well when given proper care. They seem to delight in the heat of summer and produce a tremendous growth of canes, which should be cut back considerably after the crop is harvested. They require an abundance of water. Only small patches of blackberries have so far been attempted, but some of these have proved fairly

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profitable. The Crandall's Early or California Everbearing is perhaps the most successful variety so far tested.

Loganberries do not seem so well suited to the climate as blackberries and are grown with difficulty.

GUAVA

The lemon guava is too sensitive to frost to succeed in this section, except in especially favored localities where conditions are almost frostless. The strawberry guava is somewhat more hardy and might be expected to grow in slightly protected situations.

DEWBERRY

Dewberries, particularly the Gardena variety, produce abundantly and the fruit is of excellent quality, both as to size and flavor. The Gardena is harvested during the first two weeks of May. Vigorous roots planted in the fall will often produce good crops the following spring. In fact, the fruit may prove profitable for shipment to northern markets. The practicability of such shipment, however, has not as yet been thoroughly determined.

JUJUBE

The Jujube, sometimes called the Chinese date plum, succeeds admirably, bearing very heavy crops the first year after transplanting from the nursery. The tree is hardy and grows well, but not luxuriantly. The fruit is used in making a certain type of confection, but is of no special commercial value. The tree makes a good ornamental plant, as the bright green leaves make the tree attractive.

KUMQUATS

This species of citrus fruit is not grown in California to any extent as a commercial product. Kumquats are very desirable for eating fresh or for making preserves. They will grow and produce several crops of fruit a year, although they are likely to be killed back to some extent by the frost unless protected. The variety Magumi is said to be more hardy to cold than Nagami. Kumquats deserve to be much more generally planted in home gardens. The trees are small and do not need much room for development.

LOQUATS

The loquat tree grows slowly, but makes a very attractive evergreen for ornamental purposes, as the broad leaves form a marked contrast to the foliage on the more common trees. It blooms in mid-winter and the flowers, being tender to frost, are usually killed. Trees budded on quince stock are more resistant than those grown on their own roots.

LEMONS

Lemons do well, but are not at their best in the hot, dry climate of this region. The spring winds injure much of the fruit unless well protected. As the crop comes into competition with that of other sections it has no advantage in this locality except for home use. The common Eureka lemon is perhaps the best to plant, although other varieties do about as well. The remarks regarding the care of the Pomelo apply to the lemon also.

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MULBERRIES

All varieties of mulberries may be expected to grow well and produce abundant fruit. They are valuable for avenue shade trees, but are subject to criticism by many for this purpose because of the litter made by the dropping fruit. The trees are especially useful both for shade and fruit in poultry yards.

The Russian mulberries ripen very early, while the Black Spanish (*Morus nigra*) ripens later. The Black Spanish mulberries leaf out late in the spring, but they make an extremely dense shade during the summer. The fruit of this kind is larger than that of any other variety and is quite palatable, containing more acid than the insipid Russian kinds. The varieties recommended are Black Spanish, New American, Downey, Black Russian, and Victoria.

PEACH

Peaches have not been a marked success up to the present time, although the trees grow very vigorously and in some instances bear well. In general the crop is light. The early blooming varieties are not generally subject to frost injury, and they usually bear more fruit than those which bloom later, when the air is so dry and hot that pollination is interfered with. Such varieties often produce quantities of very small, inferior and often double fruits which have abortive pits. The trees suffer more or less from sunburn of the trunks unless headed very low and pruned to thick, compact heads. Crown gall of the roots has caused much loss (see article on Diseases). Although peaches will probably never be an important or very profitable crop in this section, they can be grown for home use. The varieties doing well are: Japanese Saucer, Honey and Waldo, Admiral Dewey, Alexander, McKevitt's Cling, Georgia Cling. The Alberta has been reported as doing well in certain cases.

PECAN

The pecan is native to the moist alluvial lands along the river bottoms of southern states. While the pecan is not at home in desert conditions, the tree will grow well and produce good fruit in this section. The pecan, however, is not a promising tree from a commercial standpoint, as it would be necessary to compete with the produce coming from the cheap lands of the south.

PERSIMMONS

Persimmons are quite sensitive to the dry heat of this section. Young trees, if not protected, are sunburned badly and are easily killed. The ground immediately about the trunk should be well mulched with straw to withstand this danger. The trees when mature bear good crops of excellent quality. Fruit grown here seems to lack the extreme astringency found in the product of other localities. The Tane Nashi and Hashia have done well and can be recommended for home planting.

PLUMS

The different species of plums, and even in some cases the different varieties, react very differently to the climatic conditions and environment of Imperial Valley. Much work in testing varieties and new seedlings has yet to be done before anything approaching a complete report can be made. The remarks following should be taken as a summary of indications based on such evidence as is available at the present time.

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As a rule, the varieties derived from American and Asiatic species and hybrids between these species succeed much better than the European varieties. Such varieties as Lombard, Bradshaw and the various prunes either fail entirely or produce so little fruit as to be unprofitable. On the other hand, a number of American and Japanese plums succeed admirably and produce heavy crops.

The variety which has been observed to succeed best is the Marianna, which is a hybrid of Myrobalan and Chickasaw. This is a small red plum ripening in early May, which is especially suitable for jellies and preserves. It grows readily from cuttings. Other promising varieties which are suggested for trial as likely to be profitable are: Red June, Satsuma, Doris, Gonzales, McCartney, El Paso, Wildgoose, Wickson, Climax, Chalco, Burbank, and Chabot.

All plum trees in Imperial Valley should be headed low and pruned so as to provide shade for the trunks and main branches. The two great foes of the plum in the eastern states, the curculio and brown rot, are not known in Imperial. The roots are subject to crown gall disease, though not to a serious degree. Plum culture in the Imperial Valley appears to us as an inviting field for experiment.

POMEGRANATE

The pomegranate, coming as it does from Palestine and northern Africa, finds a congenial home in this region. The plant thrives wonderfully and fruits heavily, not being particular as to soil, withstanding a moderate amount of alkali. No special pests of this plant have been reported, although the fruit sometimes cracks and splits just before ripening. A bacterial disease, for which no remedy is known, causes some loss in certain parts where it has become established. All varieties succeed, but the variety called "Wonderful" is the most handsome and prolific known to the writer. The plants strike root readily from cuttings and are, therefore, very easily propagated.

Americans do not seem to appreciate this delicious and refreshing fruit as the Mexicans do, and it is as yet hardly known in the northern markets. It is quite likely that with a little enterprise shown in packing and marketing, this fruit would find a market at least for purposes of decoration. They would reach general consumption later as the people learn to know them. However, it is certain that any family living in the Imperial Valley and failing to grow a few pomegranates for home use is missing one of the opportunities of the country.

QUINCES

Adaptability.—Quinces flourish and produce heavily in the Imperial Valley whenever they are given sufficient water. They withstand admirably the heat of summer, provided they are headed low and so pruned as to provide shade for the trunk. Quinces are not very particular as to the quality of the soil and are fairly resistant to alkali.

So far as known, quinces have never been injured by the cold of winter and it is very rare that their blossoms are killed by spring frosts. Owing to the fact that they are used almost exclusively for jellies and preserves, there is not a great demand for the fruit on the open market. Abundant fruit for local markets and home use may, however, be produced with ease. Varieties suggested are Orange, Champion, Smyrna, Meech's Prolific, Rea's Mammoth, and Pineapple.

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ROSELLE

This is a plant long cultivated in India for its fiber, but recently introduced into this country and cultivated for the red fleshy calyces which are used in making excellent jellies and jams. Sauce made from it may replace cranberry sauce. It is an annual plant, somewhat resembling Egyptian cotton in size and manner of growth. It is well suited to conditions in Imperial, making a very satisfactory growth and producing well. No pests are at present known, and the plant deserves wider planting.

The seed should be sown in beds under cover and the plants set out as early as danger from frosts is over. The product is harvested in October and until the plants are killed by hard frosts.

STRAWBERRIES

Successful strawberry culture in this section is beset with difficulties, and a great deal of skill and patience is required to produce berries on a commercial scale at a profit. Good strawberries of high quality can be produced, and it is quite likely that the industry will eventually assume large proportions, as this section offers an advantage in earliness. The industry is just beginning to receive attention by commercial growers.

Strawberries should be irrigated every six to eight days to get good results. Plants will usually last two to four years.

The Arizona Everbearing has proved to be a good variety for this section. The main crop comes during the late spring and berries can be picked from January to September. The Lady Thompson is good, but the picking season lasts but three or four weeks. Other varieties recommended for home use are Michel's Early, Texas, and Excelsior. Growers report that such varieties as the Brandywine, grown so largely on the coast, die out entirely during the hot summer.

TANGERINE

Of the citrus fruits the Tangerines are, perhaps, the best adapted to this section. They bear heavily and regularly and have proved to be resistant to frosts which have injured other trees. They deserve more attention and should be planted in every farm orchard. The trees are, of course, sensitive to alkali, as are all citrus trees.

The investigations thus far conducted in Imperial Valley do not warrant planting the following named fruits except for experimental purposes:

Avocado	Loganberry	Pineapple
Banana	Mango	Prune
Cherry	Kumquats	Raspberry
Citron	Walnut	
Currants	Gooseberry	

TRUCK CROPS

Adaptability.—The climate and soil conditions in southeastern California favor the production of certain kinds of truck crops, such as cantaloupes or early asparagus, for which this section is noted,

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while, on the other hand, many truck crops do not thrive on account of the high summer temperatures. The vegetables of which the leaves, stems or underground parts are eaten are, with few exceptions, hardy to frost. They include cabbage, cauliflower, lettuce, spinach, beets, carrots, parsnips, turnips, radishes, and onions. None of these are seriously injured by any low temperatures that occur here and most of them can be successfully grown on a commercial scale during the coolest months. On the other hand, all are quite sensitive to heat, most of them being checked in their growth or killed by the heat of summer. The profitable production of truck products on a commercial scale will be limited largely to those crops which can be grown out

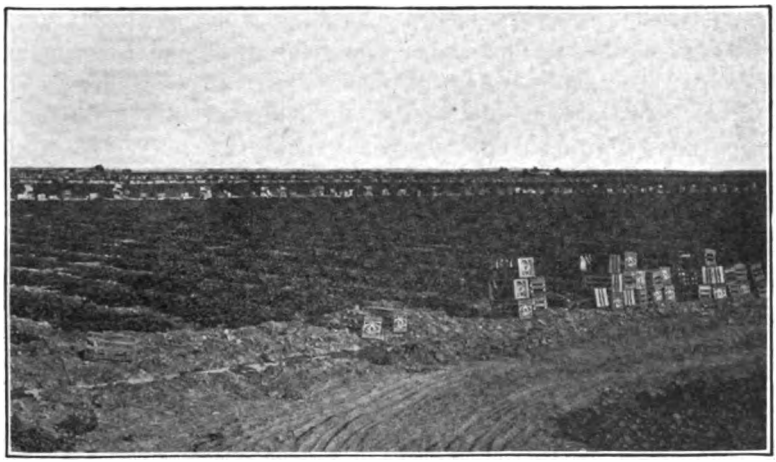

Fig. 15.—A cantaloupe field ready for picking.

of season, either during the winter or early spring. Conditions give no advantage in production other than earliness, and it is not generally considered profitable to compete with other sections where the crops can be grown as successfully as here. *A great variety of crops can be, and most certainly should be grown for home use, however. This is often neglected, when with a little care a garden would produce a large part of the food of the family. If the garden is located near the ditch where water can be secured by syphoning over the bank with a hose or through a small gate, and if long rows are used where cultivation can be done with horse power, much of the drudgery of the farm garden is removed.*

Soil and Cultural Requirements.—The production of truck crops on a commercial scale is almost limited to the sandy and sandy loam soils. The heavier clays are too cold in the spring and do not allow

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favorable water penetration and consequent root development. Good crops can be raised successfully on clay loam soils free from alkali, but for early crops and for the larger yields the softer soils give the best results.

Early and thorough preparation of the seed bed is essential to success. The addition of organic matter either by applying stable manure or by plowing under cover crops improves the soil wonderfully, and will both increase the crop and advance the ripening period. Too much stress cannot be laid upon this point, for there is nothing that will do the soils of this section so much good as the liberal addition of organic matter.

Protection from early frosts or from damage by wind storms is often necessary for crops such as cantaloupes or tomatoes. Various devices are used, but oiled paper placed over each plant seems most successful. The paper is held in place by dirt placed along the edge.

Truck crops are shallow rooted, as compared to perennials, and require more frequent but less heavy irrigations. Water is often applied every week or ten days during at least a portion of the season, although careful cultivation will lessen the need for too frequent irrigations. *The irrigator must know the condition of his soil and irrigate according to the needs of the plants, for it is only through such careful and intelligent study of conditions that success can be assured.*

Insects and Diseases.—Insects do considerable damage to truck crops in this section, and in some instances limit or even prevent the successful growing of such crops as cabbages. These are taken up under the discussion of each crop.

TRUCK CROPS

Crop	Adaptability	Varieties recommended	Dates of planting	Dates of ripening	Length of time occupying land
Artichoke	Very good	Selected	Jan.–Feb.	July–Dec.	All year
Asparagus	Excellent	Early Argenteil Palmetto Conovers Collosal	Jan.–Feb.	Feb.–Apr. Dec.	All year
Beans	Good	Blackeye Pink Tepary	Mar.–Apr. July–Aug.	June–Oct.– Nov.	2–9 months
Beets	Good	Klein Wanglebener Early Blood Turnip	Jan.–Mar. Sept.–Oct.	Jan.–July Oct.–Nov.	5–9 months
Cabbage	Very good	Any variety	Seeds planted Aug.–Nov.	Feb.–May	5–8 months
Canteloupe	Excellent	Rockyford	Feb.–Mar.	May–June	4–5 months

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TRUCK CROPS—(*Continued*)

Crop	Adaptability	Varieties recommended	Dates of planting	Dates of ripening	Length of time occupying land
Carrot	Good	Any	Aug.–Oct. Jan.–Feb.	Jan.–July Nov.–Dec.	5–9 months
Cauliflower	Good	Early Snowball	Aug.–Nov.	Feb.–June	7–8 months
Celery	Poor	Not recommended			
Cowpeas	Good	Whippoorwill New Era Unknown	Apr.–Aug.	June Aug.–Nov.	4–5 months
Cucumber	Good	White Spine	Mar.–Apr.	June–July	4–5 months
Eggplant	Very good	Mammoth Improved Spineless	Jan.–Feb.	Sept.–Nov.	5–8 months
Lettuce	Very good	Any	Sept.–Feb.	Nov.–May	3–5 months
Onions	Very good	White Bermuda	Seed, Aug.–Sept. Sets, Oct.–Dec.	Green, Feb.–Apr. Ripe May–July	7–8 months
Peanut	Good	Virginia Red Tennessee White Jumbo	Mar.–May	Sept.–Nov.	4–8 months
Peas	Good	Yorkshire Hero Telephone Stratagem	Sept.–Nov. Jan.–Feb.	Dec.–May	4–8 months
Pepper	Good	Red Chili Peppers	Jan.–Feb.	June–Dec.	8–9 months
Pineapple	Poor	Not recommended			
Potato (Irish)	Fair	Burpee's Extra Early Early White Rose Triumph	Jan. 15– Feb. 15 Aug. 20– Sept. 10	May 20–June Nov.	5 months
Pumpkin	Good	Any	June–July	Oct.–Dec.	3–5 months
Radish	Good	Any	Sept.–Jan.	Oct.–June	1 month
Rhubarb	Fair to poor	Not recommended			
Roselle	Very good		Jan.–Feb.	Oct.–Nov.	5–8 months
Spinach	Good	Any	Sept.–Feb.	Nov.–Apr.	
Squash	Fair	Yellow Crookneck Mammoth White Bush	Feb.–Mar.	June–Sept.–Nov.	3–6 months
Sweet Potatoes	Very good	Vineless Yam Jersey Red Southern Queen	Mar.–May	Sept.–Nov.	7–8 months
Tomatoes	Good	Stone Dwarf Champion	Feb.–Apr.	June Oct.–Dec.	6–8 months
Turnips	Good	Any	Aug.–Mar.	Oct.–May	3–6 months
Watermelon	Very good	Chilian	Mar.–May	June–Nov.	4–5 months

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ARTICHOKE

The Globe artichoke (*Cynar scolymus* L.) is a large, coarse-growing, hardy perennial which does well in this section, bearing heavy crops. The artichoke is not raised commercially here, but probably production on a small scale would prove profitable. It furnishes a very acceptable delicacy for the table. The plant exudes a sweet honey which attracts flies by the hundred. No way has been devised to overcome this objectionable feature.

ASPARAGUS

Adaptability.—Climatic conditions in southeastern California are apparently ideal for the production of early asparagus. Grown on a sandy loam soil, asparagus produces well and is ready to be cut sooner than that of the delta region near Stockton, where the great bulk of California asparagus is raised.

Land planted with asparagus must be well fertilized with manure to add the necessary humus and nitrogen. Applications of twenty to twenty-five tons of barnyard manure per acre have given wonderful results in increasing the yield and in improving the quality. Asparagus grown on good land, well fertilized with manure, yields from 100 to 200 crates per acre per year. The Bermuda grass which is apt to be scattered in the manure must be kept down with a hoe or shovel and not allowed to get a good start.

Asparagus seedlings can be purchased on the market or grown at home. The usual method is to plant the seed in April in rows 4 feet apart and to thin the plants to 6 inches in the row. The seedlings produced (male preferred) are transplanted in the field when a year old, in rows 8 feet apart and 16 inches in the row, the roots being set in a trench from 9 to 12 inches deep. The asparagus is not cut until two years old, or three years from seed.

After the spring cutting, the asparagus is irrigated and allowed to grow to maturity. Water is applied as required by the soil and plant, the purpose being to produce a large top. The last irrigation is usually given in August. The tops are cut and burned in December and water again applied early in January to start the new growth. Cutting begins the first of February.

The early Argenteil gives excellent results and is the variety commonly planted. Conover's Collosal and Palmetto are good varieties.

Market.—Practically all of the asparagus so far raised has been shipped to the Chicago market. Shipments continue until the asparagus from Illinois begins to come in in large quantities. Some asparagus is sold locally and in Los Angeles, the price going down gradually

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until it reaches $1.50, when further shipments stop. The season lasts from six to eight weeks.

The market for green asparagus is much better in Chicago than in New York, as the New York market prefers the large white asparagus shipped from the delta region.

No asparagus is canned, although there is room for a cannery to use the cull crop and to use the asparagus which can be grown after shipments become unprofitable.

Insects and Diseases.—No insects attack asparagus in this region, and the rust, so damaging in other asparagus sections, is not present here, and probably will never be a serious factor, as the dry air prevents a growth of the rust spores.

A disease leading to a discoloration and final drying of the tops in the fall, resulting in some weakening of the plants and a consequent reduction of yield, is prevalent. The disease is caused by a fungus (*Cercospora asparagi*), which has been reported in other sections, but has never proved serious.

BEANS

Beans, being sensitive to dry air as well as to frost, are grown as a spring and fall crop. Small experimental plantings have been tried in several parts of the valley, but no commercial plantings of any importance made until the spring of 1915. Although fair crops of lima beans have been secured by planting in the spring and harvesting in the fall, it is probable that limas will never be an important crop, as they are not naturally adapted to this dry climate. To a less degree the same applies to Pink, Bayou, and White Beans. A fair spring crop of Pink beans can be secured by early planting and a fall crop secured by planting in August. Blackeye beans do well and will yield a satisfactory crop, and probably are the best commercial beans for this section. They require from 120 to 140 days to mature. Tepary beans mature from 65 to 90 days and yield fair crops, but are probably not so profitable for this valley as the blackeyes. The main advantage of Tepary beans is their ability to withstand drought, which is of no value in this section. The market for the Tepary has not been developed, although the demand for them is increasing.

BEETS

Adaptability.—All kinds of beets do quite well when grown during the fall and winter months. Beets are sensitive to heat and are somewhat stunted by sharp frosts, but can be successfully grown for home markets.

The seed is planted in the fall, any time from August to November. The November plantings have given the best sugar percentage in tests made with sugar beets. If planted too early the cold winter weather is apt to stunt the plant and cause premature seeding. Too much water produces a rapid growth and makes a coarse beet, low in sugar content. No rule can be followed, as one has to use judgment in applying the water to get results. The Klein Wanzlebener and the Early Blood Turnip are the varieties most commonly

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planted. Sugar beets have been tried with fair success. The sugar percentage ranged from 11 per cent to 22 per cent, averaging about 13 per cent to 14 per cent. Swiss Chard, grown for its succulent leaves, thrives and produces well. Mangels are also successfuly grown.

Market.—Sugar beets have been grown in commercial quantities and shipped to the Glendale factory in Arizona, but such an arrangement was unsatisfactory. Table beets are grown for home market only, although a beet of very good quality can be raised.

Insects and Diseases.—The beet leaf hopper has caused some damage in the beets raised in experiment plats and a small beetle has caused a scarring of some beets. Sugar cane is being tried as a substitute for sugar beets in Arizona on account of the damage done by the beet leaf-hopper.

CABBAGE

Adaptability.—Cabbages have been raised very successfully in this section. The plants thrive during the fall and winter months and mature early if not attacked by aphis or the cabbage worm. These two pests have prevented any recent commercial planting. The cabbage, however, is well adapted to this region and should make a successful winter crop. All varieties so far tried have been reported as satisfactory. The seed is planted from August to October under a light protection and the young plants are reset in the field in October or November. The crop is harvested from the last of February to May. Cabbages need a plentiful supply of water. Irrigation should be frequent but not heavy.

Market.—The market for first-class cabbages is good at the time when the crop ripens in this section. The product so far has been sold in Los Angeles.

Insects and Diseases.—The main enemy to cabbage is the aphis, which appears in great number during the winter and early spring months. The cabbage worm and a small worm known as the cabbage pulsia cause considerable damage.

CANTALOUPES

Adaptability.—The cantaloupe is unusually well adapted to this region and produces abundant crops of early fruit of high quality, which carries well for long distances. Owing largely to the quick money returns, the cantaloupe has been a major crop. In 1915 nearly 6000 cars were shipped during May and June to all parts of the United States.

Old alfalfa land is especially suitable for cantaloupes. Liberal application of barnyard manure gives marked results in yield and earliness. The use of various protectors, especially parafined paper, has enabled growers to plant in midwinter and secure a very early crop. Four weeks can be gained in this way. The seed is planted in February and the melons are harvested in May and June. The various strains of the Rocky Ford are universally grown. A number of new varieties have been introduced, but with only slight success.

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Market.—Cantaloupes grown in this section are shipped all over the United States. The problem of placing 125 to 200 carloads a day is rather complicated, requiring co-operation among growers for the best results. Very efficient help has been rendered by the Department of Markets.

Yield.—Cantaloupes yield from 120 to 400 crates per acre. On the average, 65 per cent of the crop are standards (45 melons per crate), 15 per cent Jumbos, and 20 per cent Ponies.

Insects and Diseases.—The aphis is the main enemy to the cantaloupe industry, practically destroying the late crop in some seasons. Nematodes have caused some loss in some sections. (See Insects and Diseases.)

Fig. 16.—Cantaloupe field, showing paraffined paper used in protecting young vines from late frosts. Very early cantaloupes are produced in this way.

CARROT

Carrots grow well and yield heavy crops on soft soil. They should be planted in the fall and grown during the winter months.

CAULIFLOWER

Cauliflower is well suited to the climatic conditions of this section. The plants are more sensitive than cabbage plants and require more careful handling, but a cauliflower of good quality can be raised successfully.

The aphis, which is such an enemy to the cabbage, attacks the cauliflower as well.

CELERY

For the best development of the celery plant a cool, moist climate is required. For this reason celery will never be grown on a commercial scale in the Imperial Valley. Those who wish to produce a small amount of celery for home use may do so, however, by planting the seed in January or February in a shaded bed

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in a cool place where the soil may be kept constantly moist. The plants may be set out in the garden in September or October and shaded with brush until they obtain a start. The crop should be ready to harvest in December and January.

CUCUMBER

Cucumbers produce well when planted either in the spring or fall. If well matured the vines may live through the hot weather of summer, although they produce very little good fruit during midsummer. The spring crop is planted during March, while the fall crop should be sown in September. The White Spine and Early Greens produce well.

EGGPLANT

This vegetable is quite sensitive to frost, but decidedly resistant to heat. The plants flourish in this climate and the fruit matures from the middle of May through the summer, provided an abundance of water is given. The seed may be planted under a protective covering in January and the seedlings transplanted once in protected beds to make them stocky and strong. When there is no longer danger from frost they may be set out in the field. The Mammoth Improved Spineless has been reported as producing well, and we presume that other varieties also would succeed.

LETTUCE

Lettuce produces very satisfactorily when grown during the cooler part of the year. Seed may be sown in succession from the latter part of September to the end of February. All varieties so far grown have given satisfaction and seem about equally adapted to the region. Commercial plantings have proved profitable for winter markets.

LICORICE

The licorice plant is a low-growing perennial which spreads rapidly by underground stolons. It thrives wonderfully in the Imperial Valley and should be regarded as a pest and not allowed to gain a foothold.

ONIONS

Adaptability.—Onions are very successfully grown as a winter crop. The seed is planted in seed beds in September and the young plants, with tops and roots trimmed, are transplanted in October to December and harvested in March to May. The White Bermuda and Crystal White Wax are commonly planted. The sets are usually planted in two rows on top of a flat ridge, two feet or so wide. Water is run in furrows between the ridges and is applied plentifully, but gradually withheld as the harvest approaches in order to secure a firm, good shipping onion.

Market.—The market for onions has been so unstable and variable that some years the growers realize good profits and in others they have lost money, after producing a good crop of fine class onions. It is hoped that some system of marketing may be devised which will place onion culture on a more satisfactory and stable basis.

Insects and Diseases.—Thrip and flea beetles cause some damage to young plants, but if the land is well irrigated and cultivated the onions will usually come through with little serious injury. Most of the injury is done to the tops. (See Insects and Diseases.)

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PEAS

Adaptability.—Garden peas do very well during the cooler parts of the year, and the raising of winter peas has become a rather important industry. The fact that peas are often injured and sometimes killed by frosts adds an element of chance that must be considered. Peas are sensitive to heat and will not endure the summer temperatures.

Varieties.—The Yorkshire Hero gives most general satisfaction, although a large number of varieties have been tried and all do well. The Telephone Stratagem, Gradis, and Champion of England all give good results and are recommended.

Peas should be planted in rows from 2 to 3½ feet apart, sometimes two rows being planted on one ridge. The ground is cultivated until the vines begin to run.

Peas should be irrigated lightly every eight or ten days or two weeks, depending upon the character of the soil. The ground should be kept moist enough to keep the plants in a thrifty condition.

Markets.—Some peas have been grown for the Los Angeles market, but most of the product has been sold locally.

Insects and Diseases.—The aphis is the most serious enemy to the peas, although they withstand its attacks better than cantaloupes or cabbage. Grasshoppers are a serious pest, especially when the plants are young.

PEANUTS

Adaptability.—Peanuts are adapted to this section and if properly handled will give good yields. The tops make good hay, which is relished by stock, and as the plant is a legume it may prove profitable as an intercultural crop.

Peanuts must be grown on a sandy soil in order to give the bearing stem a chance to penetrate into the ground. The sandier the soil the better, as clay tends to stick to the shells and it is often hard to clean off. A good practice is to throw dirt over the center of the plant to hold the stems close to the ground. The peanuts are planted any time in the spring after danger from frosts and are harvested in about five months. Peanuts are of course irrigated through furrows. Water should be applied frequently to keep the plants in a vigorous condition, but the soil should not be soaked during the seeding and ripening period. No serious pests have yet appeared.

The common varieties planted are Virginia Red, Tennessee White, and Jumbo, although any variety will do well.

Market.—Peanuts bear as well in this section as in the established peanut-growing sections, judging from the yield secured from individual plants or from small garden plantings. The market for peanuts is good. The valley product is sold locally at prices ranging from 5 cents to 8 cents per pound.

PEPPER

Red peppers or Chilis are well adapted to Imperial Valley, but up to date not enough have been produced in the valley to supply local markets. The seed is planted in hotbeds in January and as soon as danger of frosts is past the seedlings are transplanted into permanent rows in the field. The pepper requires much water and during midsummer should be irrigated weekly. Picking begins

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in the latter part of June and continues until frost kills the plants in the fall. Medium soft soil comparatively free from alkali is best, for the pepper plant is quite sensitive to alkali.

No insects or diseases have so far been reported.

POTATO

Adaptability.—The Irish potato is not adapted to this region, but can be grown profitably on a limited scale for the early market. Being sensitive to both the cold of winter and the heat of summer, the plants have but a short time in which to mature a crop. The yield has not been high compared with those of other sections, but yields ranging from 40 to 100 sacks have been obtained in favorable seasons. During the growing season, potatoes should be watered quite frequently, but the land should not be allowed to remain saturated. As harvest time approaches, the water should gradually be withheld to improve the keeping qualities, which at best are poor.

Burpee's Early, Early White Rose, Triumph, and Salinas are varieties which have been tried with fair success.

Market.—The potatoes grown in this locality are sold locally and in Los Angeles. The early potatoes of good quality bring high prices.

Insects and Diseases.—Seed potatoes should always be treated (see article on Insects and Plant Diseases) before planting, as danger from loss through disease can then be avoided.

PUMPKIN

Although but little grown, the pumpkin is adapted to the country. If planted in June or July the vines will grow throughout the summer and mature fruit before frost. The ordinary pie pumpkin and the stock pumpkins do well. They are used chiefly as a supplementary food for milch cows.

RADISH

All kinds of radishes so far tested seem to do exceedingly well when grown during the cool part of the year. Seed may be sown in succession from late August until April. Good quality is usually secured and no particular skill is required to grow the crop. Soft soil is, of course, most desirable.

RHUBARB

Rhubarb makes a fair growth in winter, but the plants die out in summer unless a considerable expense is incurred to shade and protect them from the hot sun. In fact, rhubarb is so out of place in Imperial Valley that it is not worth while to attempt to grow it.

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SPINACH

This delicious vegetable may be grown during fall, winter, and early spring with the greatest ease. It does best on land which has been well manured. Seed may be planted from early September to February. It requires an abundance of water. All varieties do well.

SQUASH

The squashes are quite tender to frost, but resistant to heat. Both the bush and running varieties may be planted in late February or early March. They require soft, rich land with plenty of water for the best development. Growth is checked somewhat by the dry, hot weather of June and July, but some kinds, especially the running varieties, will live over the summer and produce a second crop in the fall. The summer squashes, such as Yellow Crookneck and Mammoth White Bush, do much better than the winter squashes commonly grown in the north.

SWEET POTATOES

Adaptability.—Sweet potatoes are adapted to this section, but intelligent care is required to produce a crop of good quality as there is a tendency to allow the roots to grow too fast and become coarse and stringy. The plants make a wonderful growth and if properly handled a large yield of good sweet potatoes can be secured. The seed potatoes are usually planted in sub-heated beds in February and set out into the fields when the slips are large enough, usually in March. The rows are six feet apart and the plants set every two feet in the row.

The White Vineless Yam, Southern Queen, Jersey Reds, and Yellow Jersey have been tried with success.

Markets.—The local market has been partially supplied and some shipments have been made to Los Angeles. The price obtained varies from $1.50 to $2.50 per 100 pounds.

Insects and Diseases.—The sweet potatoes are free from any special insect pests or diseases.

TOBACCO

Tobacco has been tried in a small experimental way in the Imperial Valley, but it has not been grown sufficiently to warrant commercial plantings. In the tests, Sumatra and Cuban made a fair growth and produced a leaf of fine quality. Great damage is done by the wind in whipping the leaves to pieces.

TOMATOES

Adaptability.—The spring and fall climate of this region is quite well suited to the growing of tomatoes. Although the plants are sensitive to the intense summer heat, they will live through that period and start a fresh growth in the fall. The production of tomatoes by fall planting is not usually a safe commercial undertaking, as the plants are apt to be killed by the sharp frosts which sometimes occur in the winter months.

Soil and Cultural Requirements.—The seed is planted in covered beds in February and transplanted in a month to six weeks. The plants should be allowed to grow large enough so that the stems have strength and appear to

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be slightly woody. Some get better results by planting the seed directly in the field. But as the young seedlings are quite tender better results are usually secured by growing the seedlings in a bed. The plants are set out from 18 inches to 2 feet apart in the rows which are from 4 to 6 feet apart.

Yields.—Tomatoes have yielded from 100 to 300 crates per acre. The yield is usually not large on account of the comparatively short season of growth.

Varieties.—The Dwarf Champion and Stone are the varieties chiefly grown. The Earliania is apt to sunburn; the Bulgaria has not given very good results.

Market.—Tomatoes have been grown for home market and for shipment to Los Angeles. Prices varied from 80 cents to $2.50, depending upon the condition of the market. Tomato production has not proved to be as safe or as profitable an industry as was anticipated.

TURNIPS

Turnips easily endure the cold of winter, but are killed by the heat of summer. They are, therefore, easily grown during the cool part of the year, their culture being very simple. Seed is planted at any time from October to March, either in rows and watered through furrows or broadcasted and flooded. They require an abundance of water in order to grow rapidly and produce crisp, tender roots. No serious pests have been reported. All varieties succeed.

WATERMELONS

Watermelons are suited to the Imperial Valley. They grow vigorously and produce abundantly melons of high quality. Seed is planted in March after all danger from frost is past, the subsequent treatment being much the same as for cantaloupes (which see). Watermelons are grown extensively for home use and local markets, but commercial shipments out of the valley are limited to the earliest market. The first shipments are usually made during the last week in June.

ORNAMENTAL PLANTS

Without artificial ornamentation the Imperial Valley is not an attractive place in which to live and too much cannot be said in favor of encouraging the planting of trees, shrubs, and ornamental climbers to relieve the monotony of the natural surroundings. There is no excuse for living in a house surrounded by a dusty yard, with nothing to make the environment pleasant and attractive, when there are so many quick-growing ornamental plants that with little effort can be set out, and a hot, dusty and wholly uninviting farmyard transformed into a cooler, shady, dust-free park, as beautiful as any that can be found elsewhere in southern California.

Every house should be surrounded by a lawn, as it adds much to the comfort of the surroundings. Bermuda grass is already present in the valley and as it forms a most excellent lawn, it is undoubtedly the most satisfactory grass to plant. A little occasional attention will prevent it from spreading, especially if cut regularly, but if neglected

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it soon spreads and the lawn becomes lumpy. Some follow the practice of cutting off the surface grass with a sharp hoe each spring to get rid of any rough places that may have come through neglect in cutting regularly.

GRASSES

Bluegrass will grow well during the winter and will survive the summer if the lawn is irrigated every day or two. If watering is neglected the grass will soon die out. Bluegrass and white clover have been planted together in a number of cases. This combination makes a very attractive lawn, but requires constant care to prevent its dying out.

Fig. 17.—Flowers are easily grown and add much to home life.

Australian rye grass has been planted with considerable success. This likewise makes an attractive lawn, but it requires the same constant care that bluegrass does. It is possible to plant this rye grass in a Bermuda grass lawn in the fall and thus keep a green lawn all winter long, when the Bermuda is more or less dormant.

Lippia nodiflora has been used quite extensively as a lawn plant. This is not a grass, but a plant allied to Heliotrope and Verbena. It spreads rapidly by runners, but is not hard to eradicate when desired. It is started by planting runners at intervals of a foot or so over the lawn space. Lippia stands drought very well and does not require the care that is necessary for any of the above mentioned. The main objection to Lippia is that it is quite succulent and stains the clothing much more than Bermuda does.

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SHADE TREES

There is nothing that will add more to the beauty of the landscape and more comfort to living conditions than shade trees. Trees should line every main road in the district and every farm should have a liberal planting of trees, not only to furnish shade and comfort but to supply fence posts and fire wood.

The most satisfactory tree for all purposes is the Eucalyptus. Several varieties have been grown successfully, but the following are perhaps the most favored: *E. Rostrata* (this variety grows well and furnishes good fence posts, but is very crooked in its habit of growth). *E. Rudis* (this variety makes a very attractive ornamental tree and furnishes good wood). *E. Tereticornis* (gray gum). There are offerod for sale two types of Gray gum, the broad leaved

Fig. 18.—An avenue lined with Eucalyptus trees.

and the narrow leaved. The narrow-leaved type, *E. tereticornis* var. *linearis*, is much the better type for this section. *E. Leucoxylon* (White gum). *E. viminalis* (manna gum). *E. polyanthema* (red box or Australian beech). *E. Robusta* (swamp mahogany). The ordinary blue gum (*E. globulus*) does not endure either the heat or the cold of this region.

The following deciduous trees are recommended for planting: Cottonwood (male or staminate trees); Arizona Ash; China Umbrella tree; Mexican Elder (a small tree which puts out fresh green leaves very early in the spring and is covered with white blossoms during the summer); Honey locust; fig; Mulberry (for varieties see Mulberry), *Albizzia jubibrium* and Sterculia acerifolia. Of evergreens the Pepper is perhaps the most ornamental. Carob or St. John's Bread; Live Oaks, Bagote, Sterculia diversifolia (Australian Bottle tree); Camphor tree, Monterey Cyprus, Eucalyptus, Chinese Arbor Vitae, Mission

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Olive, Acacia longifolia, Citrus, Washingtonia Canary or Date palms are all satisfactory for ornamental plantings.

SHRUBS

Shrubbery is very useful for planting at the sides of the houses and for banking along the borders of a front lawn as a boundary and to act as a background for the flowers. The Pomegranate (*Punica granatum*) and the Japanese privet (*Legustrum japonicum*) and Euonymus japonica are especially suitable for this purpose. Quick-growing shrubs are useful in screening ugly outbuildings and undesirable views. The Giant reed (*Arundo donax*) and the castor bean

Fig. 19.—The Arizona ash is a good tree for planting around a settling pool.

are very quick growing and thrive in the climate of this section. With these two plants available and so easily grown there is no good excuse for having the cow lot, pigpen, etc., in view from the dining and living room windows. The oleander in many varieties makes most excellent growth and blooms profusely in this section. The only objection to the oleander is that the leaves are poisonous, and for this reason care should be exercised that stock or children be not allowed to chew them, for, although very bitter, cases of poisoning have been reported. Several tamarisks have been planted and grow well, especially Tamarix hispida var. aestivalis. The lantana grows and blooms profusely. Several varieties of cactus and yucca are available for those who admire these types of ornamentals. The yucca bear beautiful white flowers and attractive

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dark blue berries. The Tuna (*Opuntia tuna*) grows well and may be used for a hedge or for its fruit. All kinds of roses do well. The lilac has been planted in a number of cases, although it is not especially adapted to the region. The Burning Bush (Pyrocantha) and Pampas grass can be successfully grown.

CLIMBING PLANTS

There are several kinds of annuals which will climb and cover a porch in a few months' time, although the perennial climbers are, as a rule, the most satisfactory. If these are deciduous they will not only keep the sun out in the summer but will let it in in the winter.

The Virginia creeper is one of the best known climbers in the United States; it thrives fairly well in this section. One of its most beautiful features is its brilliant red autumnal coloration. The Periploca graeca is a rapid and vigorous grower and is fairly resistant to alkali. Different varieties of grapes can be used to cover arbors. The Golden Queen is a rapid grower, with a very large dark green leaf that makes a very attractive arbor vine. Hall's Honeysuckle is also very desirable, almost evergreen and especially attractive on account of the fragrance of its flowers. The trumpet creeper (*Tecoma radicans*) is a rather diffuse grower and is adapted as an ornamental rather than a sunshield. It bears large red flowers all summer. *Tecoma gradiflora* also has attractive flowers. Other desirable flowers are *Bignonia tweediana, Clematis paniculata, Parthenocissus tricuspidata* (the Boston ivy), and the Bougainvillea. The latter is somewhat sensitive to frost and should have some protection on frosty nights. In the warmest places it may be possible to grow the beautiful *Solanum wendlandii,* which bears profusely large blue flowers.

The most desirable plants for covering an arbor are the grape vines, *Bignonia tweediana,* and the climbing roses. For quick growth the Japanese morning-glory perhaps exceeds any other mentioned, but is not very satisfactory for a permanent growth, as the dead leaves and stems soon give the arbor an untidy appearance. *Mina lobata* makes a very quick growth and produces a very attractive red and yellow blossom in the fall. The Kudsu is attractive and quick growing. The Japanese lantern plant is quite extensively planted and makes a rapid growth, although not so attractive as many perennials.

ANNUAL AND PERENNIAL FLOWERS

There is a large number of annual and perennial flowers which do well here. The following list is not given as at all complete, but as a suggestion for desirable plantings. Sweet peas do very well during the winter time (planted in September or October). The chrysanthemum does well. The California Poppy, Mignonette, Nasturtium, Phlox, Marigold, Aster, Canna, Dahlia, Geranium (in protected places), Hollyhock, Daisy, Sunflower, Smilax, Verbena, Sweet Alyssum, Stock, and Wallflower can all be planted with success.

ROSES

The following roses are especially recommended: White Kaiserin Augusta Victoria (a good white climber); Lamarque (a white climber); Crimson Rambler; Etoile de France (crimson, very good); Gruss aus Teplitz (deep red everbloomer, very good); Governor Wood (red, very good summer bloomer); Black Prince (red, very good); Papa Gontier (brilliant carmine, very good);

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Baby Rambler (deep pink, good); Caroline Testout; Captain Christy; General Arthur; Geo. Pernet (pink, good); Safrano (deep faun); Madame de Watteville (salmon, white, good); Perle von Godesburg (deep yellow, good); Sunset; Dorothy Perkins; Catherine Mermet; Helen Gould; Marie van Houtte; Golden Gate; Bridesmaid; Rainbow; M. P. Wilder; Mary J. Lang, and many others.

The Mannetti stock thrives exceedingly well in this section and most roses will do well if budded upon it. It frequently happens, however, that the great vigor of the Mannetti causes it to sucker and if the suckers are not continually cut out they will soon entirely choke out the scion.

WEEDS

Weeds have been introduced into this section largely through the irrigation water and by the importation of impure seed. Although noxious weeds are present and cause much trouble, there is no section where eradication is easier on account of intense summer heat, together with the fact that on most of the soil the moisture conditions can be almost completely controlled. Land can be irrigated to sprout the weed seed and then plowed or disced when the plants come up, thus destroying a large proportion of the annual weeds. By plowing in the summer time many of the perennial weeds can be controlled. *Rotation of crops, however, is the most successful method of combatting the weeds, and a definite system of rotation should be adopted on every farm.*

The following is a list of weeds which have proved more or less troublesome:

Johnson grass (Andropogon halepense) is found in a few places and is being eradicated as rapidly as possible, through the office of the Horticultural Commissioner. Although constant pasturing with hogs or cattle will eventually kill this weed, it is usually necessary to dig the roots up entirely or keep the plants cultivated down to the surface of the ground for a period of two years. A commercial weed killer has been used with fair success by the Horticultural Commissioner.

Wild Morning-glory (Convolvulus incanus) is another noxious weed found in very limited areas. This weed is hard to eradicate, as the time required is an important factor and too often the work is neglected before the results are complete. Constant cutting of the plants as soon as they appear or a regular cultivation with a weed cutter before they appear will eventually kill out the roots. If the work is neglected, however, the plants soon regain their original vigor. Various chemicals have been tried, but with only fair results. It is possible to kill out a small patch by treatment with carbon bisulphide, but such treatment is expensive.

Bermuda grass (Cynodon dactylon) is very common and usually spreads through the irrigation water, although the seed is spread by cattle pasturing on patches of the grass. When found in large areas, Bermuda grass can be eradicated by plowing during the hot summer months. The land should be plowed shallow and the roots turned up and allowed to dry. In small patches Bermuda grass can be dug up and the roots dried out, or it can be killed by

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covering with tarred paper of which the edges are covered with dirt to keep out all air. In asparagus plantings, where the land is apt to become foul by the introduction of Bermuda grass through the application of manure, the only way to keep the land clear is by a systematic search for the young grass and digging it out by hand labor. If this work is done often enough the grass will not start sufficiently to prevent control. If plants are allowed to get too big the work and expense is great. No chemicals have proved satisfactory so far in eradicating Bermuda grass.

Bermuda grass makes a valuble feed and on certain soils is a fair crop. The presence of Bermuda grass in alfalfa pasture, however, is of course not desirable. Rotation of crops is the only way of controlling it in pastures. When there is a good stand of alfalfa the Bermuda grass will not thrive and will only get a foothold in the bare spaces. By good farming, then, this grass can be practically controlled.

Dodder (Cuscuta) usually occurs in alfalfa fields and can best be killed by burning. An easy way is to pile dry hay on the spot and burn it. This should be done as soon as the dodder appears, as it spreads rapidly.

Wild asparagus (Aster spinosus) is a troublesome weed, especially on more or less neglected fields. It sprouts from underground roots and is quite a persistent weed. It is easily eradicated when the land is planted with alfalfa and the crop cut once a month, or by good cultivation.

Water grass (Septochloa imbricata) is common on wet land or in alfalfa fields, especially in flooded places where alfalfa has been killed out. It is a quick-growing annual which is easily killed by cultivation.

Many weeds of minor importance give considerable trouble when allowed to get well started. They can, however, be eradicated by good farming, including a crop rotation.

HERBICIDES

Thorough cultivation, crop rotation and prevention of seeding are the best methods of fighting weeds, but in some cases chemicals may be used to advantage. Some of the herbicides not only kill the weeds but poison the soil to such an extent that nothing will grow. This would, of course, make no difference in the case of walks or roads which are to be kept clean.

Salt.—Acts as any "alkali" salt.

Iron sulfate.—A 10 per cent solution sprayed on at the rate of 50 gallons per acre will usually kill all weeds except grass, but it will also injure some crops.

Copper sulfate.—A 3 per cent solution sprayed as above is effective on some weeds.

Kerosene.—This is rather weak in efficiency and sometimes dangerous.

Distillate.—Has been reported as being very effective.

Carbolic acid.—This is one of the best herbicides, as it acts quickly.

Sulfuric acid.—Effective, but not recommended.

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Caustic soda.—Used for deep-rooted or woody plants.

Arsenical compounds.—Are lasting and very effective. (White arsenic, 1 pound; washing soda, 2 pounds; water, 3–9 gallons.)

Formalin.—Is effective, and the crude product in bulk can be purchased cheaply.

Various commercial products have been used with fair success, but as all contain some one of the compounds mentioned above the various products have no special merit over these and are, moreover, as a rule, too expensive.

INSECTS AND PLANT DISEASES

Insect pests have caused much loss in this section, and owing to the fact that there is no severe freezing the control is often difficult. Although satisfactory methods of combatting certain pests have not as yet been worked out, the following account gives the best methods known at the present time.

Aphids, or *Plant Lice,*[28] are among the most serious pests, causing damage on cantaloupes, watermelons, cabbage, corn, barley, cotton and most garden crops. Spraying with tobacco extract is an effective remedy if applied thoroughly in a fine spray reaching every part of the plant, especially under the leaves. If a few aphids escape they will soon reinfest the entire field. Fumigation has been tried, but the expense is considered too great.

Destroying every infested plant in the early part of the season by burning or covering with dirt is recommended as a satisfactory expedient. Early planted barley is not apt to be so seriously damaged as a late planted crop. In the case of barley, it is well to let the field get as dry as possible, since aphids do not thrive on any but succulent growth. Aphids on roses or ornamental plants can be removed by a forceful spraying with water. If the aphids are completely washed off the plants there is little danger of reinfestation.

Grasshoppers have become a serious pest in alfalfa fields and in gardens. They become most plentiful in August. Good farming methods, with rotation of crops and thorough cultivation of all crops, including alfalfa, will do much to minimize the injury. Hopperdozers have been used, but are not effective unless used on every farm in the immediate vicinity and before the hoppers reach the winged stage. Poisons have been used successfully and are recommended for protection of garden or fruit trees where chickens are not apt to be poisoned. A good poison mixture is made as follows: Mix forty pounds of bran, two gallons of molasses, five pounds of arsenic in six

[28] A satisfactory method of spraying is described in Bul. No. 174, Ill. Expt. Sta.

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gallons of water, and distribute at the base of trees, or around a garden, by some system of broadcasting.[29]

Turkeys and chickens are great destroyers of grasshoppers and are often allowed to roam in the alfalfa field.

Crickets cause some loss, although their work is not very noticeable. No satisfactory control has been worked out.

Flea beetles injure young corn and young onions. No remedy is known.

Fig. 20.—This picture shows the cage used in catching grape leaf-hoppers. Experiments conducted in 1911 on McPherrin ranch.

Grape Leaf-hoppers appeared in Imperial Valley in 1909 and have spread to all vineyards.[29a] They cause a mottled appearance of the leaves and perhaps weaken the vines, but do little damage to the early crop, as the grapes are picked before the leaf-hoppers become numerous. The leaf-hoppers have been more or less satisfactorily controlled in other sections by the use of a hopper cage, clean winter cultivation, and a nicotine spray for the nymphs.

The alfalfa worm (*Eurymus eurytheme* Boisd.), or larva of the common yellow alfalfa butterfly, causes considerable damage to alfalfa in some seasons.[30] The damage from this insect can be greatly lessened

[29] Bul. No. 142, Cal. Agr. Expt. Sta., Grasshoppers in California, by C. W. Woodworth; Cir. No. 143, Cal. Agr. Expt. Sta., Control of Grasshoppers in Imperial Valley, by W. E. Packard.

[29a] Bul. No. 198, Cal. Agr. Expt. Sta., The Grape Leaf-hopper.

[30] For a complete discussion of the work so far done on the control of this pest refer to Bul. No. 124, Bureau of Entomology, U. S. D. A., by V. E. Wildermuth.

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and, in fact, made negligible by growing the alfalfa as rapidly as possible and by cutting early. Such operations accord with the best farm practice and will, therefore, not only prevent loss but will increase the yield. The alfalfa can be cut before the larva matures by this practice, and by keeping the edges of the fields clean and by cutting close, most of the worms will be destroyed before damage is done. By allowing the alfalfa to come into full bloom, millions of butterflies are attracted by the flowers and the eggs laid will soon develop into worms that will destroy the crop.

A bacterial or fungous parasite attacks a large portion of the worms present in the fields in the latter part of July or August, when the humidity is relatively high, and often destroys 90 per cent of the larvae.

The Corn Ear-worm makes commercial planting of sweet corn, pop corn and certain varieties of field corn very uncertain and usually unprofitable. The thick husk on the Mexican June corn prevents serious injury to that variety, but in the case of other varieties the damage is very serious. No satisfactory remedy is known.

Thrips are very common on many plants. The *Heliothrips fasciatus* causes a mottled appearance on the alfalfa leaves and often attacks cotton, causing portions of the field to turn brown, as after a frost. The *Euthrips tritici* infests nearly every kind of blossom, but causes little apparent damage. No remedy is known.

Parlatoria and *Marlatt* scales on the date palm are the only serious scale insects so far reported. Fumigation has not proved entirely satisfactory in combatting these insects. Offshoots may be freed of the scale by dipping in a cresol solution for fifteen minutes and redipping again in twenty-four hours.[31]

Nematodes are present and have caused some loss in truck crops, but have not as yet become serious. No satisfactory remedy is known, although rotation of crops is advisable.

Ants.—The red "farmer ant" (*Pogonomyrmex californicus* Buck.) causes considerable annoyance in this section. They strip young trees, vines, or alfalfa near their nests and are reported as the cause of death in young pigs. This latter report, however, has not been proved, although circumstantial evidence indicates that young pigs are killed by the sting of this ant. The ants are easily killed by a treatment of potassium cyanide or carbon bisulphide. Either of these poisons kill the ant quickly, but do not kill the eggs, and are apt to kill the vegetation adjoining the nest. One method that has been tried is to soak

[31] For more complete description refer to "The Scale Insects of the Date Palm," by R. H. Forbes, U. of Ariz., Bul. No. 56.

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a small bunch of cotton with carbon bisulphide, place this over the nest, preferably in a small hole dug in the center of the hill, and cover the hole with a bag. When time enough has passed for the fumes to penetrate to the bottom of the hole the bisulphide can be set off with a torch, thus exploding the hole and entirely disrupting the nest. This should be done at night. Paris green or London purple can be used effectively and is perhaps the best ant destroyer, as the poison does not injure the vegetation. The poison can be scattered in a ring about the nest in such a way that the ants will have to walk across it in getting food. The poison is thus carried into the nest and mixed with the food, so that both adults and young are killed. This should be repeated until the entire colony is destroyed.

Among the fungous and bacterial disease we find that those which attack the above-ground parts of plants are rare and do but little damage. Parasites such as asparagus rust, celery blight, and grape mildew can scarcely endure the hot sun and very dry air. Soil fungi and bacteria, on the other hand, such as Crown gall and Fusarium diseases of the roots of plants, may be expected to become unusually troublesome.

Smut on wheat or barley can be controlled by soaking the seed for ten minutes in twenty-five gallons of water containing one pound of formalin, then drying and seeding.

The root knot of apricots, peaches, plums, etc., causes much loss. No satisfactory remedy is known, but it is advisable to cut off the galls and paint the scars with bluestone paste.

Boll rot in cotton is more or less damaging, especially in the large leafy stalks which form dense shade. No satisfactory remedy is known.

Gum disease in citrus trees can be controlled by cleaning the infected parts and painting them with bluestone paste.

All potatoes should be treated before planting. The following formula taken from Circular No. 120, University of California Agricultural Experiment Station, by W. V. Shear, is recommended: 30 gallons water, 1 pint 40 per cent formaldehyde; soak potatoes in this solution for two hours before cutting. Remove from solution, dry and cut them.

Corrosive sublimate may be used 1 to 1000 parts water.

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LETTUCE GROWING IN CALIFORNIA

BY STANLEY S. ROGERS

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CLASSIFICATION OF LETTUCE

There are several classifications of lettuce, depending upon the character of the plant, flavor, and cultural requirements. Professor W. W. Tracy[1] has classified lettuce as follows: The cos, distinguished by its upright habit and long leaves; the butter, distinguished by its buttery flavor; and the crisp, distinguished by its hard, crisp texture. The cos has been subdivided into the self-closing and loose-closing division. The former is capable of producing a satisfactory leaf without tying, the latter requires tying. The butter and crisp classes are separated into cabbage-heading varieties, or those having solid heads, and the bunching, or those which do not form solid heads. There are other classifications influenced by the soil requirements and season of growth, such as Winter lettuce, which can withstand low temperatures and is rather slow growing; Spring lettuce, which heads rapidly, and Summer lettuce, which will endure the heat with less degree of injury than either of the above.

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For the California grower, lettuce may be divided into two classes, the large solid-head and the loose-head. The large solid-head varieties may be subdivided according to their cold and heat-resistant qualities. As an example, the Los Angeles variety has the former quality and the Iceberg the latter.

IMPORTANCE OF LETTUCE GROWING IN CALIFORNIA

The recent development of the lettuce-growing industry in California has been very rapid. The acreage devoted to the production of this crop has increased from 700 acres in 1911 to 2000 acres in 1916. Although lettuce was grown in California prior to 1911, the crop was consumed principally in the local markets. During the past few years a heavy demand for California-grown lettuce has been established throughout the United States. This is due largely to the superior quality of the crop and to the favorable climatic, soil, and moisture conditions which are found in many parts of the state.

The future of the California lettuce industry seems promising as the eastern demand is increasing so rapidly that it is sometimes difficult to supply it adequately.

LOCATION OF LETTUCE-PRODUCING CENTERS IN CALIFORNIA

The principal lettuce-growing district of California is near Los Angeles. This section produces large quantities of lettuce throughout the year and especially during the winter. It is estimated by the Los Angeles Chamber of Commerce that the production of lettuce in Los Angeles County during 1916 amounted to 900 acres, with an output of 399,465 crates. The second section of importance is located near San Francisco, Sacramento, and Stockton. During the season 1916, 200 acres of lettuce were grown in the vicinity of San Francisco and approximately the same amount was produced at Sacramento. Aside from the above mentioned localities this vegetable is grown successfully in many other parts of the state, and there is probably not a county in which it is not produced, at least in small amounts, during some season of the year.

COST OF PRODUCTION

The cost of production is largely dependent upon the character of the soil, season of the year, experience of the grower and the area planted. The following cost-per-acre data have been secured from several experienced growers and at the University Farm Garden.

[1] American Varieties of Lettuce. United States Department of Agriculture. Bulletin 69, p. 12.

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	Per acre
Plowing 12 in. deep	$ 3.00
Harrowing	.30
Clod mashing	.50
Constructing raised beds	10.00
Seed (3 lb. @ $2.50)	7.50
Growing plants (in seed beds)	2.00
Removing from seed bed and transplanting to field	20.00
Hoeing once	8.00
Irrigating four times	8.40
Harvesting and crating (2000 doz.)	13.50
Total	$73.20

Several of the above costs are variable. If the raised beds are made by hand the cost would vary from $25 to $30, instead of $10. During certain seasons of the year one irrigation would be sufficient instead of four. In figuring the labor costs it is assumed that the laborer will receive twenty-five cents per hour, nine hours constituting a working day.

YIELDS AND PRICES RECEIVED

The yields vary from 1500 dozen to 2500 dozen marketable heads per acre, with an average yield of 2000 dozen. Growers who ship to wholesale houses receive eight to twenty cents per dozen heads, the usual price varying from ten to fifteen cents.

In table I will be found the average monthly quotations for lettuce on the Los Angeles market from 1911 to 1915, inclusive.[2] These figures represent the prices which the wholesale broker quotes to the retail buyer.

TABLE I

Month	Year	Av. price per crate	Month	Year	Av. price per crate
January	1911	$ .80	July	1911	1.00
	1912	1.37		1912	.82
	1913	1.04		1913	.96
	1914	.95		1914	.98
	1915	.87		1915	1.05
February	1911	1.00	August	1911	1.00
	1912	1.27		1912	.95
	1913	1.16		1913	.87
	1914	.93		1914	.94
	1915	.81		1915	1.10

[2] Compiled by Professor A. T. Potts of the Texas Agricultural College, while studying at the University of California.

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Month	Year	Av. price per crate	Month	Year	Av. price per crate
March	1911	1.15	September	1911	1.19
	1912	1.12		1912	.95
	1913	1.07		1913	.95
	1914	1.25		1914	.91
	1915	.94		1915	1.14
April	1911	$1.15	October	1911	.99
	1912	.96		1912	.82
	1913	.92		1913	.53
	1914	.94		1914	.78
	1915	.85		1915	1.00
May	1911	1.69	November	1911	1.12
	1912	.82		1912	.71
	1913	.80		1913	.53
	1914	.83		1914	.80
	1915	.80		1915	1.05
June	1911	.82	December	1911	1.08
	1912	.82		1912	.72
	1913	.69		1913	.64
	1914	1.00		1914	1.02
	1915	.85		1915	1.10

Average price of lettuce during five years, 1911–1915 inclusive. compiled from table I.

TABLE II

Month	Av. price per crate	Month	Av. price per crate
January	$1.01	July	.82
February	1.03	August	.84
March	1.11	September	.91
April	.96	October	.96
May	.99	November	.97
June	.84	December	1.03

It will be noted that the highest prices are received from November to March, inclusive, and especially from December to March. The demand for California lettuce is heaviest during these months for long-distance shipments to the colder sections of the United States. During the summer months the eastern demand for California lettuce is comparatively small, due to the large amount of local lettuce in those markets.

Estimating the crop to be 2000 dozen heads and the price at 12½ cents per dozen, the grower would receive a gross income of $250 per acre, and a net income of $176.80. Considering that the land is in use only three to four months this would appear to be one of

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the most satisfactory vegetables for the commercial and home garden. It will be understood that such returns are obtained only under favorable conditions by experienced growers.

CULTURAL REQUIREMENTS

Soil.—Lettuce is very exacting as to soil requirements and is best suited to a rich light loam. It should never be planted on soils of poor quality, for, although the plants will grow, the texture of the leaves will be tough and the heads small, both of which are very undesirable qualities.

Moisture.—Lettuce requires considerable soil moisture throughout its entire growing period, making irrigation necessary except during the rainy season. It is, however, easily ruined by an excess of water which makes possible a stem rot on the plants.

Climate.—Lettuce is a hardy vegetable and will stand, without injury, a low degree of temperature. Under this condition, however, the growth of the plant stops and a moderate temperature is desirable while the plants are growing. This crop will stand cold much better than heat, making it impossible to produce lettuce of good quality during the summer in many of the interior valleys of the state. When the weather is too hot and dry the plants will produce seed instead of heads.

PREPARATION OF THE SOIL

At the time of planting the soil should be in the finest possible condition and free from all weed growth. Many growers apply from fifteen to twenty-five tons of manure per acre. This should be applied long enough in advance of planting so that it may be plowed under and completely rotted by the time the field is ready for use. In the fall before the rains have commenced, the field should be heavily irrigated before plowing, but in the winter and spring months there is generally a sufficient amount of moisture without irrigation. After the soil has been worked into good condition, raised beds or ridges should be made either by the use of a hand hoe, or a special cultivator attachment. The latter implement is generally used where a large area is planted and the former where a small amount is grown. The beds should be from twelve to eighteen inches wide, four to six inches high, and the spaces between them ten to fifteen inches. After the beds have been prepared the field should be irrigated a few days before planting in order that the soil may settle.

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Fig. 1.—Constructing raised beds.

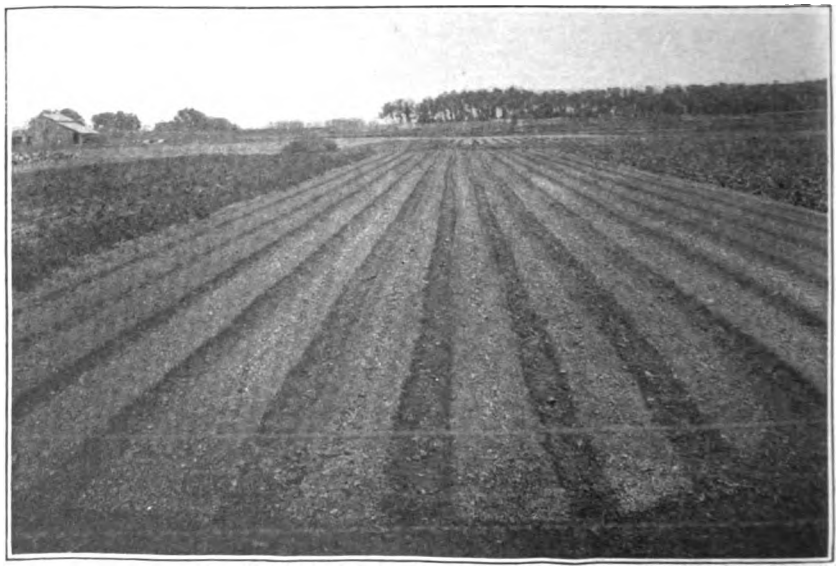

Fig. 2.—After the raised beds have been roughly constructed, they may be smoothed over with a garden rake and irrigated.

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PLANTING AND CARE OF THE SEED BEDS

The time of planting is governed entirely by the climate, and it is very important that the grower be acquainted with his local climatic conditions before growing this crop. For the interior valleys of the state the planting season generally starts during the last of August and continues until the first of March. Many growers make a first planting of the seed from the middle to the last of August, a second in October, and a third during January or February. Along the coast, where the climate is more moderate, it is possible to grow lettuce successfully during any month of the year.

Fig. 3.—Sunken seed beds.

There are two methods for growing lettuce, both of which are used extensively in California. The first is by planting the seed directly in the field, sowing it in drills on the borders of the raised beds; the second is to sow in seed beds and transplant the young plants into the field when they have attained the desired size.

There are several forms of seed beds in use, the most common being the sunken beds, which vary from three to six feet in width and eight to fifteen feet in length. The earth taken from these beds is hoed up to form a levee around each in order to aid in irrigating. Before planting, a heavy coating of well-rotted manure should be spaded under and the soil should be heavily irrigated just previous to seeding. The seed may either be broadcast or sown in drills, and

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immediately covered with one-half inch of earth. If the soil is of a heavy nature so that it is liable to run together and bake when irrigated, a thin coating of well-rotted, screened stable manure should be applied on the surface before seeding. It will aid the seed in germinating if strips of burlap be placed on the soil and allowed to remain until the young plants are appearing at the surface. In removing this covering the young plants should not be exposed too suddenly to the light. During the warm months it is often necessary to irrigate several times before the young plants appear. The water may be applied either through a sprinkler or by flooding, using only a small stream so that the tender seedlings may not be injured. The amount of irrigation which the beds will need depends largely upon the character of the soil and the season of the year. During the early fall the beds are often irrigated three or four times a week, while later in the season one or two irrigations will prove sufficient. When the plants are one and a half to two inches tall the beds may be weeded and the plants thinned, leaving the distance between every two not less than one inch.

Under ordinary conditions the plants should remain in the seed beds six weeks, although the time required will vary from one to two months with the season of the year and care of the plants. When planting directly in the field three to four pounds of seed will be sufficient for one acre; at the University Farm Garden, 2600 square feet of seed beds raised a sufficient number of plants for one acre in the field.

When quick-growing plants are desired the seed should be sown in hotbeds in preference to the open beds. This form of bed is occasionally used during the winter and early spring.

Removing the Plants.—Plants may be transplanted when they are from two to four inches tall, the larger size being preferable during the warm weather. Before removing, the plants should be hardened by stopping the irrigation a few days in advance so that their growth may be checked. A few hours before the plants are to be removed they should be thoroughly irrigated in order that as much soil and as many fibrous roots as possible may be taken up with the seedlings. There are two methods for removing the plants. Those who have had considerable experience may pull them by hand. Those with limited experience, and especially if the soil is of a heavy nature, should dig them with the aid of a trowel or shovel. The plants should be constantly covered, after being removed, until they are planted in the field, for if exposed to the sun many of the small roots will be killed. If the seedlings are too large the leaves and roots should be

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cut back. The best size of plant for transplanting is one having a top three inches tall and roots two inches long.

FIELD CULTIVATION

Planting.—The distance between the plants in the field varies from eight to fifteen inches. Where a variety producing large heads is grown, such as the Los Angeles, the plants should not be less than twelve inches apart in rows twelve inches apart, but if a smaller variety is used the spaces between the plants may be slightly reduced. If the seed has been sown directly in the field the plants should be

Fig. 4.—Setting lettuce plants in the field.

thinned when they are from two to four inches tall, and the vacant spaces filled with those which have been removed while thinning.

Irrigation.—A few days before planting, the field should be irrigated in order to settle the earth in the raised beds, and to show how far up on them the water will come. If this is not known many of the plants will be so high on the beds that they will not receive sufficient water, while others will be so low that they will be injured from an over-supply. As soon as the plants have been transplanted the field should be thoroughly irrigated, and it is especially important while they are young that frequent irrigations be given. In applying the

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water care should be taken that it is not allowed to flow over the tops of the beds, and it will be found much more satisfactory to use a small stream, allowing it to run between the beds slowly, and thoroughly soaking into them, than a larger stream flowing more rapidly.

The number of irrigations which the field will require can only be determined by the condition of the plants. It is sometimes desirable to irrigate every week throughout the season, while under other conditions one or two irrigations will be sufficient. There should always be an adequate amount of moisture in the soil from the time the plants have commenced to head until they have matured, because the

Fig. 5.—"Scandigie" used for transplanting.

character and size of the heads is influenced to a great extent by the quantity of soil moisture present.

During the late spring if it is desirable to hold the crop in the field for a short time after it has matured, no more water should be applied, as it will increase the liability of the plants going to seed.

Cultivation.—When raised beds are used all of the cultivation will have to be done by hand, and the number of times which the field should be hoed will vary from one to five during the season. This will depend upon the character of the soil, the weed growth, and the thoroughness with which the beds have been made and irrigated. The soil need not be hoed between the beds unless there is a heavy growth of weeds. Occasionally water will flow over the tops of the beds and

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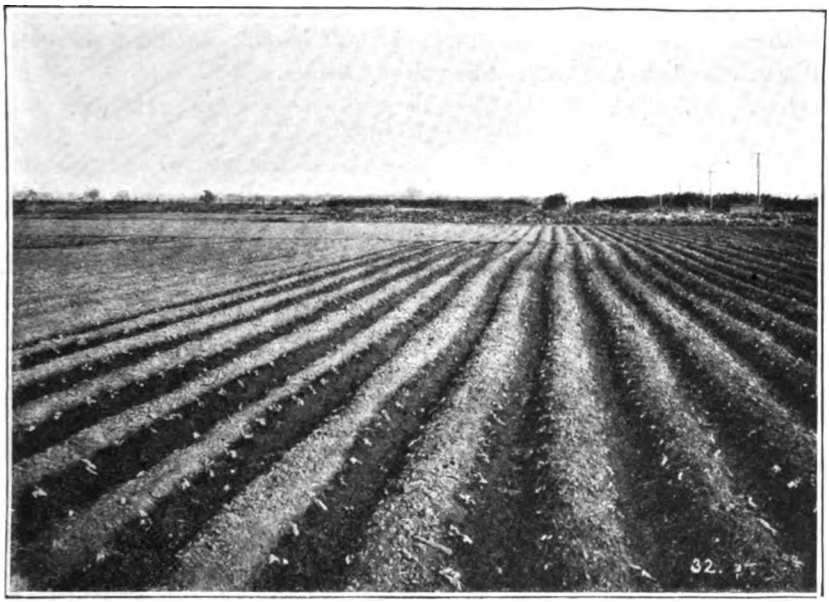

Fig. 6.—Lettuce plants should be set at the edge of the moist earth.

Fig. 7.—When irrigating lettuce water should never be allowed to cover the plants.

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these low places should be hoed after each irrigation if the soil has a tendency to run together, for the growth of the plants will be retarded if the earth close to them is allowed to harden.

HARVESTING[3]

The time required to mature a crop of lettuce varies with the season, the character of the soil, and the care. Plants set in the field during September should mature during November and December. Plants set in the field during November will mature from February to April, inclusive, and those transplanted during February and March will mature from April to June.

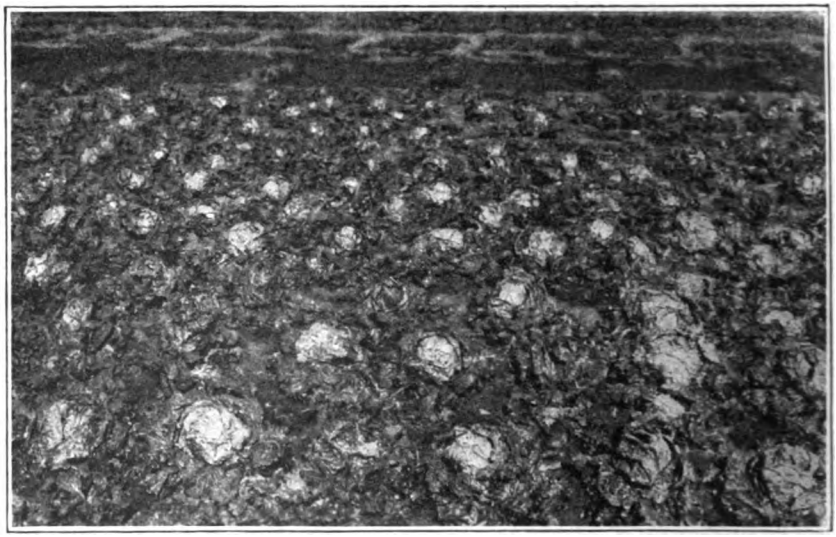

Fig. 8.—Lettuce should remain in the field until the heads have fully matured.

The period of growth at which the crop should be harvested depends largely upon the season, market requirements and prices. The California market demands a large solid head and the crop should remain in the field until it has reached this condition.

In harvesting it will be found most efficient to employ three men; one man cutting and two placing the heads in piles. During the spring when the weather is warm it is best to cut the lettuce early in the morning while it is cool and place it in the shade during the heat of the day, unless it is possible to ship immediately. The crop should never be cut when the heads are wet, as they will heat and quickly rot

[3] The following calendar is applicable to the interior valleys of the state, and especially to central California.

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when packed in that condition. The field is generally gone over from three to five times during the cutting season, and the heads should be cut at the base, using a knife having a blade ten to twelve inches in length. After the crop has been harvested it should be handled very carefully and sold as soon as possible.

PACKING FOR SHIPMENT

Lettuce should always be packed for shipment in crates, especially when disposal is to be made at a considerable distance from the

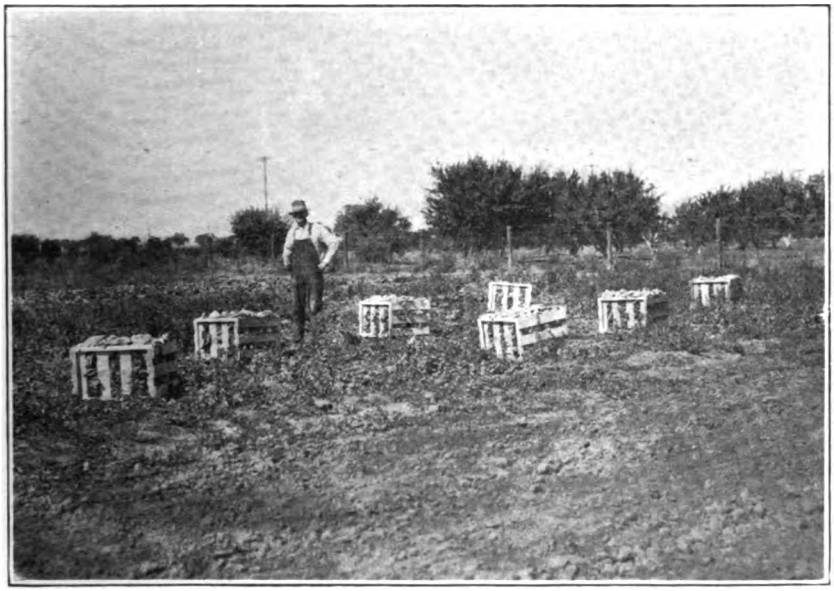

Fig. 9.—Lettuce packed in the field for local market or packing house.

garden. There are three sizes of crates commonly used: the Los Angeles crate, which holds from three to five dozen and is twenty-four inches in length, eighteen inches in width and thirteen inches in height; the pony crate, which holds two dozen heads of ordinary size lettuce and is about one-half as large as the Los Angeles crate; and the field crate, which is about twice as large as the Los Angeles and holds about eight dozen heads of ordinary size lettuce. The Los Angeles and pony crates are most commonly used for long-distance shipments.

After the lettuce is cut it is hauled directly to the packing house where it is sorted, trimmed and repacked. That which is to be shipped a considerable distance, and especially during warm weather, should

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always be protected from the heat; a layer of chopped ice should be placed between the bottom and the second layer of lettuce, and one on the top layer. If the pony crate is used the ice is put on the top layer only. The inside of the crates should be lined with heavy paper, which prevents the contents from drying and aids in keeping it cool. Lettuce is shipped in iced or refrigerator cars, the temperature of which should be kept as even as possible.

In filling the crates, the bottom layer should be packed with the stem ends down and the others reversed, thus protecting the heads from injury in transit. After the crates are packed they are placed immediately on cars and rushed to their destination. An ordinary sized car holds from 300 to 310 crates.

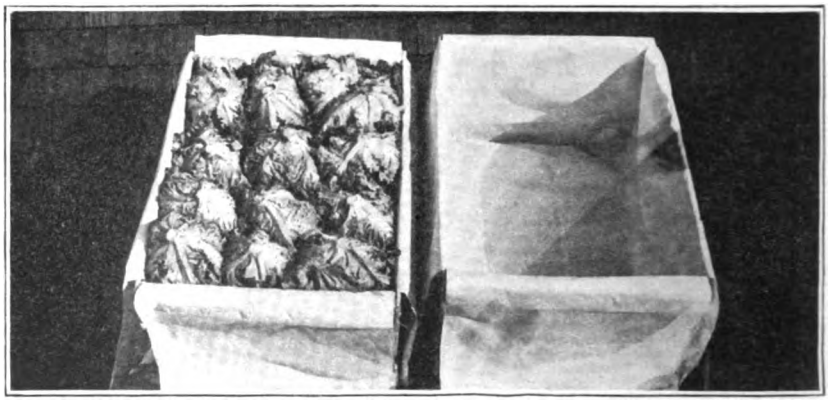

Fig. 10.—Lettuce re-packed for long distance shipment and empty crate lined with paper preparatory to packing.

VARIETIES

There are a large number of varieties of lettuce under cultivation. Robinson in his book, "The Vegetable Garden," names over one hundred and twenty-five.[4] At the University Farm Vegetable Garden during the past season, eighty different varieties were grown, most of which did well under our conditions. Of this large number, however, there are a comparatively few which meet the demand of the California buyers. The four leading varieties which are now being produced in this state are the Los Angeles or New York Market, the Iceberg, the California Cream Butter, and the Hansen.

Los Angeles.—This variety is by far the most popular and is especially adapted for long-distance shipments. The head is large, solid, tender, an excellent shipper, and matures quickly. The outer leaves are dark green in color,

[4] W. W. Robinson, "The Vegetable Garden," pp. 362–399.

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but the head is well bleached and excellent in flavor. This variety will withstand cold without injury but is not adapted to maturing during hot weather as it quickly goes to seed.

Iceberg.—This variety is grown extensively and is especially adapted to maturing during the hot weather. In size and general appearance, it is quite similar to the Los Angeles variety, the main difference being a reddish tinge on the edges of the leaves. This is a good shipping variety .

California Cream Butter.—This variety is commonly grown and is similar to the Big Boston. It has a rich creamy taste from which, presumably, it derived its name. The head is light green and tinged with brown. The outer leaves are slightly spotted with inconspicuous brown spots.

Hansen.—This is a desirable variety for local market. The leaves are a lighter green than those of the Los Angeles. The heads are solid and have a good flavor.

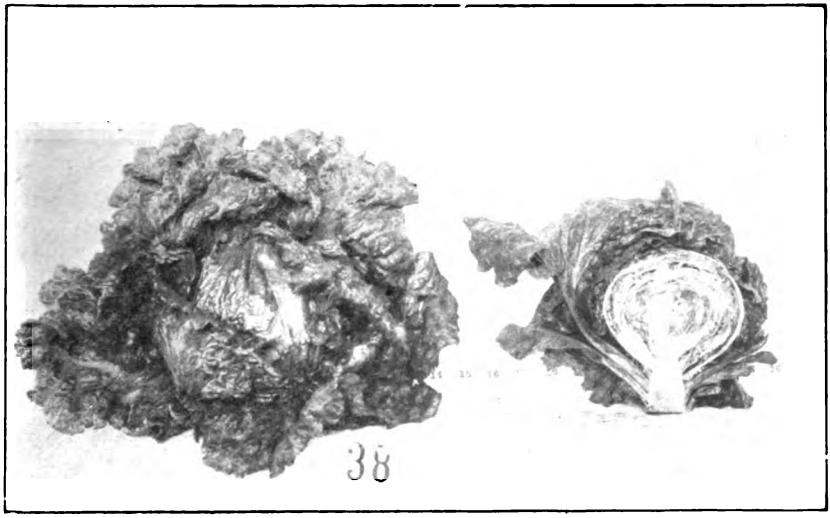

Fig. 11.—Los Angeles.

CROP TROUBLES

Securing a Stand of Plants.—It is often difficult, especially during hot weather, to secure a satisfactory stand, either when planting directly in the field or when sowing in seed beds. Aside from the climatic influence, the germinating power of the seed, over-irrigation, or applying insufficient quantities of water are often responsible for this condition. In controlling this trouble the grower should determine which of the foregoing causes is responsible and remedy it if possible. (For detailed directions for the construction and care of the seed bed, see page 7.)

Stem Rot.—This disease is present in the fields during winter and early spring; it is most prevalent on heavy soils, and especially severe

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where drainage is poor. Soon after it appears, the plants will become a sickly yellow color and the stems will rot at the surface of the ground. These diseased plants may appear promiscuously throughout the field, or may be in certain well-defined areas. This is a fungus disease which thrives best under excessive moisture conditions. For control the grower should improve the drainage so that no water will be allowed to stand on the field, and the beds should be made high enough so that the water will not stand directly around the plants.

Sunburn.—This trouble is characterized by a blackening of the edges of the leaves inside the heads. It is often impossible to know that this condition exists without cutting into the head. Severe losses are sometimes occasioned, especially in the crop maturing during the late spring. Occasionally these affected plants will rot during shipment. The cause is a period of excessive hot weather from the time the plants are half-grown until they have commenced to head. Planting in the fall or early spring will largely control this disease; if the weather is very hot and dry during the spring the plants should be irrigated frequently.

Failure to Produce Solid Heads.—This condition is caused either by a poor quality of seed, an insufficient supply of moisture, or unfavorable climatic conditions, such as excessive hot weather while the plants are maturing. This may be largely overcome by using only well-selected seed and applying sufficient moisture at the time the heads are maturing. During the late spring when the weather is hot the crop should be harvested immediately after the heads have matured.

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CIRCULAR No. 161
MARCH, 1917

POTATOES IN CALIFORNIA

BY J. W. GILMORE

The principal regions of California in which potatoes are grown at the present time, are the Delta region, comprising parts of San Joaquin, Sacramento, and Contra Costa counties; the Salinas Valley in Monterey County; the Napa and Sonoma Valleys in their respective counties, and the regions comprising parts of Santa Barbara, Los Angeles, and Riverside counties. The average yield per acre in these several localities differs widely, ranging from 4500 to 12,000 pounds. In general where soil conditions are optimum the yields vary according to the mean temperature of the growing season; the best yields being obtained in localities with relatively cool summer temperatures. Hence, the interior valleys are not so well adapted for potatoes as the cooler coast sections. It should be noted, however, that potatoes are grown in all counties of the state, and by improved culture methods the potato acreage can be extended.

Soil Considerations.—In order to meet the requirements for profitable potato yields a soil must be superior in three respects—drainage, organic matter content, and preparation. Of these three, granted that there is reasonable fertility present, drainage is most important. The good potato soils in all parts of the country are those that are either naturally or artificially well drained. On the other hand, there are good soils in potato-producing regions which are not fit for potatoes because they are not well drained. Even though a soil be heavy in texture, it will become friable and productive if it is well drained and contains a fair amount of organic matter.

The problems of good drainage and organic matter content are inter-related, because they both have to do with affording the growing crop with a sufficient and constant supply of moisture. This is a very important consideration, for tubers do not develop well under

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conditions of a fluctuating moisture supply. But in addition to aiding in the maintenance of a sufficient and constant supply of moisture, organic matter ameliorates temperature conditions to the end of improving both yield and quality of the crop. A soil that is deficient in organic matter will be of poor physical condition for potatoes, will vary in moisture content during the growing season, and will become warm and cool as the temperature of the air changes.

Preparation.—The importance of early and thorough preparation cannot be overemphasized. It is estimated that this procedure gives half the assurance of the crop. The land should be plowed as deeply as possible in the fall and allowed to remain rough during the winter, in order that it may be benefitted by the winter rains and weather. As early in the spring as possible it should be worked with disc and harrow as often as may be, in order to keep the surface in good condition and to destroy early germinating weeds. It is desirable that the interval between opening the furrows before planting and closing them afterward shall be as short as possible. In case the land cannot be plowed until spring it should be plowed deeply and worked frequently, in order to give it sufficient compactness to facilitate the distribution and retention of moisture.

The Seed Set.—The yield of potatoes on reasonably good soil will increase with the size of the set. But there is a limit in size above which the cost of the seed will be greater than the value of the extra yield and below which the yield of marketable tubers will not pay for the growing of the crop. The results of experiments, extended in time and place, indicate that the seed set producing the greatest returns over the cost of seed and of growing the crop should be between two and three ounces.

Whole or Cut Sets.—The best results have followed the use of cut sets. For optimum yields the size need not be so large for whole tubers as for those cut. It has been found that whole tubers, when size is equal to cut sets, often give somewhat better results than cut sets. This is because the cut sets lose something by evaporation and contact of the fresh surface with the soil, are more subject to attack of diseases in the soil, and also because there are more eyes on the whole tuber. Hence, the whole tuber has a better chance of setting forth its strongest eyes as sprouts.

On the other hand, the planting of whole tubers is more often questionable because the small whole tuber is likely to represent the progeny of a weak producing hill. For example, in a crop of potatoes where 18 per cent of the total crop were unmarketable or culls, it was found that 76 per cent of these culls were from weak or unproductive

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hills. These culls were planted in comparison with cut sets of the same size from large tubers. The yield of the culls was only 56 per cent of the yield from the cut sets. It follows, therefore, that the safe practice is to plant cut sets from large tubers rather than small whole tubers, unless they represent productive hills. If, however, the whole tubers, though small, are from productive hills, these may be better for an additional reason: that small tubers are likely to be less mature than large tubers; and after the tubers have passed through the required rest period, stronger sprouts emanate from immature than from mature tubers. This is the reason why stronger sprouts come from the bud end than from the stem end. This also explains why second crop potatoes are often better for seed than those of the main crop.

Cutting.—Since the strongest buds are near the bud end of the tuber the seed set should be cut in such a manner as to include one or two of these strong buds on each piece. With this in mind the tubers should be cut so as to expose as little cut surface as possible. Usually a diagonal cut rather than a straight lengthwise or crosswise cut gives best results. Skill in this work is gained only by experience and when one is expert a decision as to how to cut can be made while the tuber is brought by the one hand to the knife in the other.

There are mechanical cutters on the market, but these do not perform good service, for there is much waste from small pieces which often possess strong eyes.

Seed potatoes are often infected with diseases. The presence of these can generally be detected by cutting off a small portion of the stem end. If there appears either in the center or around the edge a spot or ring of brown, the tuber should be cast out, for this is likely to be the fusarium wilt and will be transmitted to the growing crop.

It is a widespread practice to sprinkle some dry, dusty material over the tubers when cut. The substances usually used for this purpose are gypsum, lime, ashes, and road dust. Neither experience nor experiment has shown any decided advantage in this practice except under those conditions when the addition of one of these substances materially benefits the soil; or when the cut tubers may not be planted for several days after they are cut. Gypsum shows a benefit more often than the other substances, but this is because nearly all soils are benefitted by gypsum. Likewise ashes give good results when the soil requires potash. One must use lime with care, however, for lime promotes conditions in the soil favorable to the growth of disease fungi, hence the crop may be injured more by disease than benefitted by the lime. Seed sets should be planted as soon after cutting as possible, within twenty-four hours at most.

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Sprouting.—It is a good practice when possible to sprout seed tubers before cutting and planting. This is usually done by placing the dormant tubers in diffused or subdued light for about three weeks before planting. Sometimes it is well to cover the tubers with a light layer of moist straw, especially if they are placed out of doors. By this process short, stubby and somewhat green sprouts about one-fourth to three-eighths inch long grow out from several eyes. They are not so easily broken off as if sprouted in the dark. There are several advantages in sprouting as suggested. In the first place only those tubers showing vigorous sprouts need be selected for planting, thus a more perfect stand is assured, and a more uniform growth is also secured. In the second place, recognizing that rhizomes come out only at the nodes or joints of the sprout underground, by sprouting, more nodes will form beneath the surface than if the tubers begin their sprouting in the ground. Thus, the yield of tubers is likely to be increased. Another advantage is that there may be additional time to finish preparing the land if that has not been completed for an early planting.

Planting.—If the soil is rich, deep, well drained and well prepared, potatoes may be planted as close as 12 inches in the row, with rows 20 inches apart. But under usual soil conditions in California it seems best to plant from 12 to 14 inches in the row with rows 36 to 42 inches apart. In this manner the crop may be cultivated by horse labor without seriously disturbing the vines in their position and growth. The wider distance is essential under conditions where soil is poor and the moisture supply inadequate.

The best depth for potatoes under normal conditions is four to five inches. If planted too deep the tubers will be small and of poor quality. If planted too shallow they will be of variable size, unshapely and often greened by exposure to the light. In heavier soils the shallower depth may not be exceeded, but in lighter soils the greater depth may be followed. There are several makes of machines on the market for planting. The main advantage in their use is in their enabling one to plant the largest possible area in good season. Their main defect is that they do not work the soil thoroughly and deeply, and in poorly prepared soils the tubers are likely to be planted too shallow.

Time of Planting.—The optimum time of planting potatoes in California extends over a considerable period. In the coast regions of southern California the planting may begin in the early winter months, especially for crops that are designed for the early market. In most regions, however, the planting may begin in early March and

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continue until June, the prospects for largest yields diminishing as the season advances. For the second crop, the planting is usually begun in late July or early August.

There is a general correlation between the yield and the period of maturation. The longer the growing season the greater the yield. Early potatoes require from 70 to 90 days to bear a crop, while the late varieties require from 130 to 150 days. It is recognized that potatoes are good food at any stage of growth, but immature potatoes do not possess good keeping or shipping qualities.

Culture.—If the land is deep, rich, and well prepared, and if the seed sets have been well chosen and prepared and seasonably planted, little more can be done to insure a crop. Cultivation may be given as the conservation of moisture or the destruction of weeds may require. Usually three or four cultivations are as many as the crop will pay for. The first cultivations may be deep, but the later treatments should be shallow, because of the danger of disrupting the shallow feeding rootlets. It is best to cultivate potatoes level, but under conditions where water is excessive they may be ridged in order to secure drainage. Under conditions where the crop has to be grown entirely by irrigation they may also be ridged and especially if the rows are close together, for it is inimical for free water to come in contact with the growing tuber for any length of time.

Irrigation.—Under most conditions where irrigation is necessary it has been found that about 1¾ acre feet of water are necessary to produce a good yield. This amount should be put on in three or four applications, beginning when the plants are approaching full growth and repeated at intervals of fourteen to eighteen days until the vines show signs of maturity. A light cultivation should be given after each irrigation to break the crust in the furrow and conserve the water applied. The water should be applied by furrows rather than by flooding. Sometimes in light soils a furrow between every alternate pair of rows is sufficient, but a furrow between every two rows is best. The potato does not thrive under a fluctuating moisture supply, hence, every attempt should be made by irrigation and cultivation to keep the moisture supply sufficient and constant.

Diseases.—There are many diseases attacking the potato in California, and because of our mild climate and other conditions favorable to development they are often difficult to control.

Perhaps the most destructive disease is the Fusarium wilt. This pest may be detected by a brown spot or ring appearing on the fresh surface of the stem and of the tuber when cut. Such tubers for seed

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should be cast out. If, however, they are planted, or if the disease is already in the soil it manifests itself by a sudden wilting of the plant as it comes into vigorous growth. The plant soon turns brown and dies. When this disease becomes established in the soil six or seven years are required to eradicate it, during which time no host plants should be grown upon the land. The remedial measures against this disease are, therefore, rotation of crops and the choice of disease-free seed.

The disease second in importance is Rhizoctonia. The presence of this disease may be detected by small wart-like and dirty specks, or excrescences, on the surface of the tuber. It manifests itself by a yellowing and wilting of the growing plants as they approach full size. The ravages of this disease may be lessened to a considerable extent by treating the seed tubers in a solution of formalin, one pound to thirty gallons of water for one and one-half to two hours according to the prevalence or intensity of the disease. If the tubers have sprouted before they can be treated it would be well to treat them in a solution of corrosive sublimate (mercuric chlorid), four ounces to thirty gallons of water, for one and one-half hours. This treatment does not injure the sprouts as formalin does. It must be remembered, however, that corrosive sublimate is an active poison and every precaution should be taken in the interests of plants and animals.

Scab.—Oospora: This disease manifests itself by large dried or scabby spots occurring on the tuber, both before and after they are dug. The appearance on the plant is not so marked as with the diseases previously mentioned; but the yield from infested fields is materially reduced. The treatment for seed tubers supposed to be infested is the same as for Rhizoctonia mentioned above. But it does not seem feasible by the evidence of experiments to treat tubers for planting in soil that is already infested with either disease. One pound of formalin will treat from three to five sacks of potatoes, according to the intensity of the diseases, or the prevalence of dirt on the tubers.

Another disease that is very prevalent and destructive to potatoes in the Delta region is that commonly called Leaks (Rhizopus nigricans). This disease manifests itself after the tubers are dug and usually occurs while the tubers are piled in sacks on the levees awaiting shipment. The effect is to cause the potatoes to collapse, the water running away from a large pile in a stream. Sometimes the disease does not manifest itself until the tubers are in transit or in storage.

The disease attacks only those tubers that have been broken, chipped, or abraded in digging and handling. The trouble cannot be

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absolutely prevented or cured, once it has made its attack, but precaution and care can be exercised in the digging and handling to avoid bruising or breaking the skin.

Of the several insects that attack potatoes the most noteworthy are the flee beetle, which punctures the leaves, thus inviting and favoring the attack of fungi; the eel worm, which occurs in rich soils and finds in the growing potato a rich supply of food; and the tuber moth, the larva of which eats holes and cavities in the tuber.

The flee beetle cannot be entirely prevented from attacking the potato, but it can be discouraged by sprays of bordeaux mixture. To combat the eel worm it is necessary to plant clean seed sets, or if the soil is already infested to plant other plants non-attractive to the pest until the soil is rid of it.

Mulching.—In some parts of the state, especially in the interior valleys, where the summers are warm, potatoes do not grow to desirable size. Encouragement and advantage may be offered by mulching the ground with broken or partly decayed straw, or other light waste material. This mulch should be applied after the vines are well along in their growth. If the ground has been well prepared and early cultivations are given this mulch may serve in lieu of late cultivations. The effect of the mulch is to keep the ground cooler and more constantly moist than it would otherwise be, thus simulating soil conditions in more northern latitudes.

Fertilizing Potatoes.—There are few experimental data for California bearing on the question of the use of fertilizers. It should be noted, however, that the benefits from fertilizers depend upon several factors, prominent among which may be mentioned the type and character of the soil and the amount of moisture available. In general where fertilizers are desirable a mixture containing 2 to 3 per cent of nitrogen, 6 to 8 per cent of phosphoric acid, and 8 to 10 per cent of potash, will probably give good results. A mixture of forty pounds of sulfate of ammonia, 120 pounds of acid phosphate and eighty pounds of sulfate of potash per acre will be sufficient for all but very light soils. The mixture should be applied in the furrow and stirred in the soil before planting.

Varieties.—While many varieties of potatoes have been tried in California, but few have been found well adapted. The following have been found of some merit in various parts of the state:

Early.—Chili: A pink, smooth-skin potato, adapted to the northern Sacramento Valley and coast sections.

Early Ohio: A pink-skin tuber, grown largely in the southern part of the state.

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Early Rose: White and red. Adapted to a wide range of conditions and used both for a first and second crop.

Medium.—American Wonder: A white, shapely potato of good yielding and cooking quality.

British Queen: A white potato which may be used also for late.

Late.—Burbank: The most widely grown potato in the state. It has a tendency to grow too large and long, and if not carefully grown its eyes will become rather prominent and deep.

There are a number of other varieties which may be good for certain localities and conditions, such as Triumph, Pearl, and Uncle Sam, but those mentioned have been tried extensively and perhaps are more certain one year with another.

Cost of Production.—The following figures represent as nearly as can be presented, average costs of the various stages in potato production. In some instances the range is wide. The figures under market value represent average for several years past and do not refer to prices at present prevailing.

Preparing land and planting—	
Plowing and preparing land ($2.50–$8.00) (Coast sections)	$ 5.00 per acre
Plowing for planting ($0.00–$3.00) (Delta sections)	1.50
Seed ($2.00 per sack)	12.00
Preparing seed—cutting	1.00
Preparing see—disinfecting	.35
Planting (six acres per day)	.90
Growing the crop—	
Cultivating ($0.00–$2.00)	1.00
Hoeing ($0.00–$2.00)	1.00
Irrigation ($0.00–$10.00)	6.00
Harvest—	
Digging (machine) ($1.00–$200)	1.50
Picking up and sacking (after machine)	.06 per cwt.
Digging, picking up and sacking (by hand) (10c–20c)	.15 per sack
Sacks	.10
Hauling off (five miles)	1.00 per ton
Covering sacks (on levee or in field)	.10
Hauling to levee (Delta)	.50

Market Value of Yield—

High	$2.50 (1sts) per cwt.
	1.75 (2nds)
Low	.65 (1sts)
	.50 (2nds)
Average	1.00 (1sts)
	.65 (2nds)
Culls	.15

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CIRCULAR No. 162
MARCH, 1917

Bacillary White Diarrhoea or Fatal Septicemia of Chicks

AND

Coccidiosis or Coccidial Enteritis of Chicks

BY J. R. BEACH

INTRODUCTORY NOTE

Bacillary white diarrhoea or fatal septicemia, and coccidiosis, or coccidial enteritis, are the two most prevalent and most serious diseases of chicks. In California coccidiosis is very prevalent while outbreaks of bacillary white diarrhoea are comparatively infrequent. The name "white diarrhoea" has led to more or less confusion in the minds of many poultrymen regarding the exact nature of this disease. Since any disorder of very young chicks is liable to be manifested by a disturbance of the digestive system and consequent diarrhoea, with thin yellowish-white droppings which bring about a deposit of white material on the feathers below the vent, many outbreaks of so-called "white diarrhoea" are in reality due to errors in hatching or rearing and in no way related to the infectious disease, bacillary white diarrhoea.

By some writers, coccidia are given as one cause of "white diarrhoea" and, therefore, coccidiosis is classified as one form of white diarrhoea. Such a classification has caused considerable confusion in the minds of poultrymen and is, according to the observations made at this station, wholly unjustifiable. In none of the outbreaks of coccidiosis investigated by this station have there been any symptoms or history which might be confused with those of bacillary white diarrhoea. In the following pages the two diseases are taken up separately and an attempt made to describe them in such a manner as to avoid any confusion regarding their identity.

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BACILLARY WHITE DIARRHOEA OR FATAL SEPTICEMIA OF CHICKS

Character of the Disease.—Bacillary white diarrhoea is an infectious disease of young chicks caused by an organism called *Bacterium pullorum.* The symptoms are usually a tendency to stay under the hover or stand in patches of sunlight, followed by droopiness and loss of appetite, and lastly diarrhoea, the droppings being usually light colored. Frequently the feathers below the vent become soiled with a chalk-like deposit which in long-standing cases may become as large as a walnut and block up the vent, a condition known to poultrymen as *pasting up behind.* The disease usually makes its appearance during the first week after the chicks are hatched, but the losses may continue for four weeks or more afterward.

Post-mortem Lesions.—The stomach, gizzard and intestines are usually pale and filled with a slimy fluid. The lower portion of the intestines is sometimes filled with feces due to the blocking up of the vent.

The liver is either a uniform dull ochre color or dull ochre streaked with bright red. This is one of the most prominent and constant lesions. The size is usually normal and very often the organ is quite soft. The gall bladder is normal in acute cases, but in cases of long standing it is distended with dark-colored bile.

The heart, spleen and kidneys are usually paler than normal, but this condition can be detected only by a practiced eye. The lungs are usually congested.

There is always an unabsorbed yolk in the abdominal cavity. This is the most characteristic lesion. The amount varies, according to the course of the disease, from a full-sized yolk to a piece no larger than a pin head. The consistency of the yolk also varies with the course of the disease; in the early stages it is large and watery, while in the cases of long standing it is smaller and gelatinous or cheesy in consistency. The color is usually yellow or yellowish brown.

Diagnosis.—Symptoms and lesions identical with those described can be produced by a variety of causes. They include improper incubation, overheating or chilling in the brooder or in shipment, feeding too soon after chicks are hatched, and improper feeding or overfeeding. Therefore, *pasting up behind* with chalky material, or the presence of lesions similar to the ones described, should not be considered as a positive indication that the chicks are infected with bacillary white diarrhoea. A *positive* diagnosis can be made only by a careful bacteriological examination of a dead chick.

Method of Infection.—The chicks which are infected with the bacillary white diarrhoea and do not die, continue to harbor the germs

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throughout their lifetime. In hens such infection is localized in the ovaries, in males in the testicles.

Such fowls usually give no indication of the infection, are apparently in perfect health,[1] and very often are good layers. Post-mortem examination of such hens usually reveals ovarian lesions consisting of cysts and discolored yolks, although frequently a slight congestion of the ovaries is the only visible evidence of infection to be found. In males, the only lesion found is a congestion of the testicles and oftentimes this is absent. Pure cultures of *Bacterium pullorum* can be obtained from the ovaries or testicles of infected fowls. Some of the eggs laid by infected fowls contain these germs in the yolk; chicks hatched from such eggs are infected when born, and the infected chicks spread the contagion to the others. One such eggs in an incubator would be sufficient to infect the entire hatch. Infected males eliminate the germs in the spermatic fluid and thereby infect hens during the process of breeding.[2] Chicks may also be infected by placing them in contaminated brooders. The most common source of infection, however, is hatching eggs laid by infected hens.

Course and Prognosis.—As a rule, this disease runs a very rapid course, death taking place within twenty-four to forty-eight hours or less after symptoms are noticed. Frequently, however, symptoms are present for as long as three weeks before death ensues. The percentage of mortality is usually high, the average being more than 50 per cent. Frequently as many as 90 per cent of the flock will die, but occasionally the loss will be slight.

Treatment.—Various methods of treating bacillary white diarrhoea have been recommended from time to time, but further investigation has in all cases shown them to be of little value. At the present time there is no satisfactory method of treating the sick chicks. Buttermilk or sour skim-milk seem to have a beneficial effect in some instances, but cannot be relied upon to check the disease when once it has started. However, this is just as satisfactory as any treatment yet suggested, and has the added advantage of being an excellent food for the chicks. Therefore preventive measures are more important than treatment for controlling this disease.

Preventing the Entrance of the Infection Through Infected Eggs.—Obviously, the certain way of preventing eggs from infected hens from getting in the incubator is to use hatching eggs from flocks

[1] One outbreak of a disease of mature fowls in which the percentage of mortality was high and the cause of which was *Bact. pullorum* has been reported. (Jones, F. S., Report of the N. Y. State Veterinary College, 1911–12.)

[2] Infected mature females can also transmit the infection to healthy mature females in the same flock.

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known to be free from infection. If a poultry breeder has had no trouble with bacillary white diarrhoea in his own chicks or in chicks hatched by others from eggs produced by his flock, this may be taken as assurance that his flock is not infected. It is also possible to determine positively whether or not a flock is infected, either by bacteriological examination of the eggs, or by means of a blood test known as the "macroscopic agglutination test." The first method would necessitate that the hens be trapnested and an examination made of each egg. Since an infected hen may lay no more than one infected egg a month, or even less, frequently the egg examination would have to be made daily for a long period and the amount of work required would make this method impracticable. The agglutination test has been proved to be reliable by numerous investigators.[3] In Connecticut and Rhode Island upwards of twenty-five thousand fowls have been tested by this method. To make the test, a small amount of blood is drawn from the wing vein of each fowl. This is forwarded to a laboratory where the test is made. The results of investigations have shown that in order to pick out all the infected fowls two or more tests are necessary. Since it costs about ten cents per fowl to make the test, the necessity of making repeated tests would make this method too expensive for practical use. However, one test will show whether or not the flock is infected and herein lies its chief practical value. If a tested flock contained no reactors to one test, it could be considered as free from infection.

Preventing the Infection from Spreading to Healthy Chicks after it has Gained Entrance to the Flock.—To prevent the disease from spreading after it has gained entrance in a flock, all the sick chicks should be removed and destroyed, the house thoroughly cleaned and disinfected, thereafter cleaned daily, and the chicks divided into small flocks, the purpose of this being to prevent a large number of chicks from becoming infected in case all the infected chicks were not removed. An added advantage of having the chicks in small flocks is that any new cases that develop can be more easily detected.

Preventing Chicks Hatched from Non-infected Eggs from Becoming Infected.—The ways in which non-infected chicks could be infected after being put in the brooder house would be by placing them in a contaminated brooder or by the infection being carried in from infected flocks. Since the white diarrhoea germs are comparatively easy to kill, a *thorough* cleaning and disinfection of the brooder before the chicks are put in will destroy all infection; and, if care is taken to prevent the infection being carried in from diseased flocks by visitors, attendants, dogs, etc., there is little danger of the flock becoming infected.

Results of the Use of the Agglutination Test at this Station on a Small Number of Birds from Two Different Flocks.—Flock No. 1: In June, 1914, two dead chicks were brought to the Veterinary Science

[3] Jones, Report of N. Y. State Vet. College, 1911–12, Journal of American Society of Instructors and Investigators in Poultry Husbandry, 1916; Gage, Mass. Agr. Exp. Station, Bul. 148, 1914; Rettger, Kirkpatrick and Jones, Storrs Agr. Exp. Station, Bul. 185, 1915; and others.

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Laboratory for diagnosis. The owner reported that a majority of the chicks he had hatched that year had died when they were a few days old. A bacteriological examination of these chicks resulted in the isolation in pure culture from the heart blood and liver of *Bacterium pullorum* and, therefore, the disease was diagnosed as bacillary white diarrhoea. On inquiry it was learned that the chicks were hatched from eggs produced on the premises. Therefore, it seemed probable that the hens were the source of the infection and it was decided to attempt to pick out the mature fowls that were infected by means of the agglutination test. It was not possible to obtain permission of the owner to test more than four of the hens, and a small quantity of blood was drawn from the wing vein of each of the four fowls and the test made. Three of the hens reacted and one gave no reaction. Two of the reactors, and the non-reactor were procured from the owner and a post-mortem examination made. The ovaries of both of the reactors were found to be diseased and pure cultures of *Bacterium pullorum* were obtained. The ovaries of the non-reactor were normal.

Flock No. 2: In August, 1916, a poultry raiser reported a disease among his chicks which upon investigation proved to be bacillary white diarrhoea. Arrangements were then made to test some of the hens of the flock which produced the eggs from which the chicks were hatched. One hundred fowls were tested. About 65 per cent gave positive reaction. Several of the fowls were then killed and post-mortem examinations made. All the reactors killed had diseased ovaries while the ovaries of all of the non-reactors were perfectly normal. As far as could be determined by outward appearance, all the fowls tested were in perfect health.

Fifty more fowls from this same flock were tested in February, 1917, 50 per cent giving positive reactions. Post-mortem examinations were made of none of these fowls. All were apparently in perfect health.

COCCIDIOSIS IN CHICKS

Coccidiosis or coccidial enteritis is an infectious disease of chicks caused by protozoon organisms known as coccidia (*Coccidium tenellum*). The intestines are usually the only organs infected, but occasionally lesions are found in the liver or lungs and other organs. Coccidia may exist in small numbers in the intestines of chicks without causing any apparent harm, but when they are present in sufficient numbers they destroy the mucous membrane lining of the intestines and death results. The caeca or "blind guts" are the portions of the intestines most seriously affected. The disease is seldom seen in chicks under two weeks or over four months of age.

The usual history of outbreaks of coccidiosis is that the chicks do well until they are a few weeks old, when they begin to look unthrifty, droop and gradually die. It is not at all uncommon for entire flocks of chicks to die in the course of a month or six weeks. The symptoms of the disease do not differ materially from those of some other diseases and are, therefore, merely suggestive of coccidiosis.

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The feathers of sick chicks become ruffled and soiled; there is a marked paleness of the skin of the head and of the visible mucous membranes. The sick chicks are inclined to separate themselves from the rest of the flock and stand "humped up" with their eyes closed for hours at a time unless disturbed. Usually diarrhoea, which is sometimes bloody, is present. A bloody diarrhoea can be considered as positive evidence of coccidial infection. Chicks usually show symptoms for at least three or four days before death occurs.

The post-mortem lesions usually consist of an enlargement of the caeca. The contents of the enlarged caeca may be either normal in consistency and brown or reddish-brown in color, semiliquid and bloody, or solid and yellowish white, brown or red in color. Occasionally there is no enlargement of the caeca nor abnormal appearance of the contents, so the absence of enlarged caeca cannot be taken as an indication that the chicks are not infected with coccidiosis. Frequently there is an inflammation of the lining of the intestines throughout their entire length. All other organs are, in most cases, apparently normal. Symptoms and lesions very similar to these, however, may be produced by causes other than coccidiosis; therefore, a microscopical examination is necessary for a positive diagnosis. If coccidia are the cause they will be found in large numbers when the contents of the intestines are examined microscopically. Coccidiosis is spread by the organisms which pass out with the droppings of diseased birds. Other chicks become infected by drinking water or eating food, litter, or particles of soil contaminated by the droppings from diseased chicks. It has been demonstrated that these organisms will remain alive in soil for a year or more. Therefore, chicks that are allowed to run in yards in which infected chicks were kept the year previous are very likely to become infected.

There are no drugs which have been found to be practical for treating diseased chicks. Seemingly good results were obtained by emetine hydrochloride, but the cost of this drug prohibits its use. It is known, however, that the presence of acid and a perfectly healthy condition of the mucous membrane of the intestines inhibits the multiplication of these organisms and it is also known that unless they are present in large numbers very little damage is done. Therefore, the disease can be controlled if the mucous membrane is kept in a perfectly healthy condition and the intestinal contents acid. These conditions may be brought about by feeding the chicks sparingly of grain and mash (a superabundance of food in the intestines causes malfermentation which lowers the resistance of the tissues to the action of the organisms), and by feeding sour milk or buttermilk in large quantities, the lactic acid in the milk inhibiting the multiplication of the organisms. Good results can sometimes be obtained by giving hydrochloric acid in the drinking water, one teaspoonful of the acid per quart of water. If buttermilk or sour milk is unobtainable hydrochloric acid may therefore be used. Every effort to obtain sour milk should be made, however.

Investigation at this station has shown that the above measures can be put into successful practical application and that the follow-

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ing sanitary measures and feeding method are an efficient means for controlling the disease:

Sanitary Measures.—If only a few chicks are visibly sick when the presence of the disease is discovered, remove them from the flock and either keep them isolated or kill and burn them, preferably the latter. If. however, a large percentage of the flock are visibly infected, remove only the worst cases, which should be killed and burned.

If possible, put the chicks on new ground. If this is not possible, plow or spade the yards. Thoroughly clean the houses with a strong hot disinfectant solution. After the floors have dried cover them with a thin layer of litter (shavings, chopped alfalfa hay or straw). Sweep out this litter *daily,* burn it and put fresh litter in the houses. The litter will collect the droppings, thus preventing them from sticking to the floor, and making the daily cleaning easy. Continue this daily cleaning until the chicks are old enough to roost, and for a longer period if all signs of the disease have not disappeared. If all signs of the disease have disappeared by the time the chicks are old enough to roost, deep litter can be put in the houses and the daily cleaning confined to the dropping boards underneath the roosts. It is advisable to exclude the chicks from the dropping boards by means of wire netting. Keep all feeding and drinking vessels scrupulously clean at all times.

Feeding Method.—Feed a *small* amount of grain night and morning. Feed mash during the middle of the day, never leaving it before the chicks longer than two hours.[4] Feed greens as usual. Keep buttermilk in fountains constantly before the chicks. The restricted grain ration will keep the chicks hungry and they will consume large quantities of buttermilk. If too much grain and mash are fed and the chicks drink large quantities of buttermilk, sour crop is very liable to result. There is no danger of this occurring, however, if the amount of grain fed is small.

In most instances, if the above sanitary measures and feeding method are carefully followed, improvement in the condition of the flock will be noticeable in three or four days and all signs of the disease will have disappeared in from two to four weeks. The buttermilk will cause the droppings to be somewhat "watery," but this should not be considered as being at all dangerous.

The above feeding methods should be employed from the start, when chicks are put in houses and yards in which a flock infected with coccidia was kept the year before. Buttermilk has considerable food value, so that normal growth and development will be obtained.

Report of Three Outbreaks of Coccidiosis Successfully Controlled.—Three outbreaks of coccidiosis at this station have been successfully controlled by the employment of the above described sanitary precautions and feeding method. The first outbreak occurred in April, 1915, in a flock of 150 chicks, five and one-half weeks old. The presence of the disease was shown by some bloody droppings which upon micro-

[4] In severe outbreaks withhold the mash entirely until the condition of the flock shows marked improvement.

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scopical examination were found to contain large numbers of coccidia. The flock was then carefully examined and eight chicks picked out as visibly sick. They were at once isolated. A microscopic examination of the droppings of each of these eight chicks showed them to contain large numbers of coccidia. Although all the visibly sick chicks had been removed, bloody droppings containing large numbers of coccidia continued to appear on the dropping boards. This showed that although there were no visibly sick chicks in the flock there were some badly infected ones and that it was impossible to remove all the infected chicks by the isolation of all visibly sick.

The daily cleaning of the houses and "buttermilk diet" were then adopted. No more visibly sick chicks were noticed, and at the end of three weeks all evidence of the disease had disappeared. The chicks also showed normal growth, many of them weighing 1½ pounds at nine weeks of age.

The second outbreak occurred in April, 1916, in a flock of 150 one-month-old chicks which were kept in the same yard as the flock just described. *More than half* of the chicks were *visibly sick* when the presence of the disease was discovered. The procedure for controlling the disease was the same as in the previous outbreak with the exception that *none* of the sick chicks was removed. A decided improvement in the condition of the flock was noticed within three days, and all evidence of the disease had disappeared a month later. Only one chick died from coccidiosis.

The third outbreak occurred in January, 1917, in a flock of 730 two-months-old chicks. About 60 per cent of the flock were visibly sick when the presence of the disease was discovered. Post-mortem examinations of several of the dead chicks showed the lesions in the caeca to be unusually severe. The control measures for this flock varied somewhat from those used in the previous outbreaks. The brooder house was immediately cleaned and disinfected and thereafter cleaned every other day instead of daily. A small quantity of grain was fed night and morning, but no mash was fed at any time. Buttermilk in fountains was kept constantly before the chicks. This much restricted grain ration kept the chicks very hungry and they consumed about forty gallons of buttermilk daily. Almost immediate improvement in the condition of the flock was noticed and in less than three weeks all evidence of the disease had disappeared. The entire loss by death was only thirty-five chicks. The above described control measures were carried out for three weeks when the chicks were placed in colony houses, mash again fed, and the amount of buttermilk given greatly reduced. All the chicks made normal growth.

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CIRCULAR No. 163
APRIL, 1917

SOME FUNDAMENTAL CONSIDERATIONS AFFECTING THE FOOD SUPPLY OF THE UNITED STATES

Memorandum Prepared for the Committee on Resources and Food Supply of the State Council of Defense

BY
THOMAS FORSYTH HUNT

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MEMORANDUM PREPARED FOR THE COMMITTEE ON RESOURCES AND FOOD SUPPLY OF THE STATE COUNCIL OF DEFENSE

BY THOMAS FORSYTH HUNT

This memorandum prepared for your Committee has been entitled "Some Fundamental Considerations Affecting the Food Supply of the United States."

It is true that here and there I have added concrete suggestions. These, however, are merely incidental, being presented rather as illustrations of the broader aspects of the problem, and are not intended in any way as a comprehensive programme of action.

Any statements made herein are predicated upon a three years' war. If the war lasts only three months or continues ten years, then the statements made may need to be materially modified.

It is a matter of great satisfaction to be able to advise this Committee that it is impossible to starve the American people. There is no occasion in the United States for the disease known as "fear of starvation." Our families cannot be brought to such distress as is known in Belgium, Poland and Germany, and which is feared in England. This is due, primarily, to the fact that the United States raises two crops that neither our enemies nor our allies raise in any such considerable quantity. These two crops are Indian corn and cotton. They render the United States impregnable. We raise an abundance of everything needed for human consumption with certain exceptions, which I will state later, and normally, in addition, produce considerable quantities for export.

Broadly speaking, Indian corn is used for the production of butter and animal fats, while the cottonseed which we produce in growing cotton furnishes oil equivalent to one-half of the butterfat produced in the United States. About one-third of all the land plowed in the

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United States every year is planted to Indian corn. An acre of Indian corn has nearly twice the value of an acre of wheat for human consumption. These resources are in addition to those of either our enemies or our allies. We are therefore unassailable from the standpoint of breadstuffs and fat.

This does not mean that serious consideration should not be given to the food supply, nor that many people may not find it difficult to obtain money to supply themselves with sufficient food, but rather that the problem should be looked at from the right point of view. It is a problem on the one hand of producing materials for export in order to maintain a favorable balance of trade, thus also doing our duty to our allies by keeping them from starvation, and on the other hand it is a problem of the proper distribution of supplies used for domestic consumption. Distribution may be greatly affected by our military necessities. England has sought to speed up her manufacturing industries, because a nation cannot continue indefinitely to buy products without having products of an equivalent value to sell. For many years foodstuffs and cotton have served to maintain a favorable balance of trade, although in recent years manufactured products have become more, and foodstuffs less important.

I recommend to the Committee that it express itself as not favorable to any attempt to control production by legal or military means. The feeling on the part of producers that some authority will try to control production is a sure means of preventing it. An abundant supply of food is more important than a cheap supply, and the best method of securing an abundant supply is high prices to the producer.

Germany is said to have been successful, through its Food Dictator, in the distribution and control of the use of many food supplies in the larger centers of population. It has failed for the most part in its attempts to control production. In some cases its activities are said to have been an important factor in the serious shortage of certain products, such as fat.

Even in the matter of distribution and control of use, only certain products can be handled with any considerable success. A crop like wheat can be handled successfully for the following reasons:

1. It is harvested on any one farm over a very limited period. Thus it can be requisitioned at the minimum of expense.

2. It is not easily secreted, among other reasons, because it must be fabricated before it can be used; first, ground, and second, for the most part baked into bread.

3. Wheat can be stored indefinitely.

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4. When made into bread its use can be controlled. Bread checks are fairly effective.

A crop like potatoes cannot be controlled successfully because:

1. Potatoes can be secreted. They can be easily buried and do not require any particular fabrication for consumption; all that is necessary is to drop them into boiling water. A demand for 80 per cent of the farmer's wheat crop can be made reasonably effective under military necessity, but a like demand for potatoes may not secure more than 50 per cent. Dean Barrows informs me that the potato supply of Belgium disappeared immediately upon German occupation. It is easy enough to bury potatoes in such small lots and in out-of-the-way places, as to make it impracticable for any military organization to requisition them.

2. Potatoes cannot be stored indefinitely. Recognizing that potatoes were worth more for human consumption than would be the hogs which were produced from them, the German Government had a considerable number of the hogs of the country butchered, and took over the potatoes which would have been required to feed them. The potatoes rotted, because it was subsequently found that they were not needed for human consumption, and the nation suffered for lack of fat which the hogs would have supplied had the Government not disturbed the farmers' normal procedure.

A crop that is produced daily cannot be economically controlled. There is no way of determining how many eggs a flock of hens will lay on a given date; even by daily espionage, and even if it were possible, it would cost more than the product is worth. Examples might be indefinitely multiplied.

It is a matter to be considered whether a proper balance of trade cannot be more effectively maintained by extending our production of barley than by restricting the production of barley for the purpose of raising more wheat. If there be any actual danger to California because she now imports considerable quantities of wheat from Washington, Oregon and the Dakotas, it does not follow that the solution of the problem lies in an increased production of wheat in California. I use this illustration to suggest a type of inquiry, rather than for the purpose of expressing an opinion on the subject. The best method of meeting this possible contingency is a matter to which this Committee should give serious attention. Later I will have a suggestion to make.

Broadly speaking, we may divide the dollar which the consumer pays for food products into three parts, not necessarily exactly equal, but perhaps nearly so.

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One part—let us say, one-third—goes to the producer of the product; one-third goes to the distributor, including the transportation companies and the wholesalers; and one-third goes to the retailer. The last one-third is due largely to the service which the consumer demands, and for which he insists on paying. So far as we have the evidence before us, the German Government's success in handling the food supply has consisted largely in reducing the cost of retail distribution, and in controlling the amount of food which people were permitted to eat. I think I may reassert without any fear that we shall never in this country be compelled to limit, by legal or military action, the amount of food consumed; but I believe it would be entirely possible as a military necessity, to reduce the service which is now rendered by the retailer, and to eliminate from that service for war purposes a considerable body of our citizens. I suggest that your Committee give some consideration to this aspect of the problem.

Food for human consumption can be segregated somewhat empirically, yet quite significantly, into five classes:

> (1) Protein foods, such as meat, fish, fowl, eggs, cheese, beans and nuts; (2) Fats, including the body fat of animals (pork, beef, and mutton), butter, and vegetable oils, such as olive and cottonseed oils; (3) Starchy foods, sometimes popularly referred to as "bread foods," such as wheat, rye, barley, rice, and potatoes; (4) Fruits and vegetables; (5) Sugar. In this group for convenience I include chocolate, tea and coffee, because all of the products comprised in it are imported wholly or in part.

It is important, as Germany has found to her sorrow, to maintain the proper balance between these five groups of foods. I would suggest, therefore, as each requires somewhat separate consideration, that during the conference today, the Committee appoint a subcommittee of two or three members for each group; that during the luncheon recess each committee formulate concrete suggestions concerning the particular class of foods to which it has been assigned, and that these reports be made the first order of business on reassembling in the afternoon.

Professor Jaffa has prepared for me a table* showing the value at the point of consumption of suitable foods for the average family of five persons, based on present prices. These I have classified into five groups as above suggested:

* This table is given in detail on page 12.

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Food Materials	Total Expended per family Ave. Min.	Ave. Max.	Total Ave. Min.	Ave. Max.
Protein				
Milk	$68.40	$87.30		
Meat	136.80	194.00		
Eggs	28.50	72.75		
Beans	2.10	2.40	$235.80	$356.45
Fats				
Butter	29.75	50.75		
Oil and fat	17.00	29.00	46.75	79.75
Starchy Foods				
Flour	22.80	24.25		
Cereals	12.00	13.58		
Macaroni	2.80	2.80		
Rice	2.10	2.40		
Potatoes	28.50	38.80	68.20	81.43
Fruits and Vegetables				
Fruits	28.50	48.50		
Green vegetables	27.36	34.92	55.86	83.42
Sugar				
Sugar	19.00	27.20		
Tea and coffee	10.20	21.90	29.20	49.10
			$435.81	$650.55
Per person per day			$0.238	$0.356

Sundries, including such articles as chocolate, corn starch, baking powder, sago, gelatine, flavorings, spices and all dainties and extras, have been omitted.

The family consists of father and mother, son 16, daughters 10 and 3 years respectively.

I think it is fairly obvious from this table that the public discussion of our food supplies has been placing the emphasis in the wrong places.

Attention is also called to the fact that while quantities of the first four classes of foods are produced for export, sugar, in the fifth class, comes principally from Cuba and Hawaii. Since sugar is produced continuously throughout a considerable portion of the year, it has not been necessary to store large supplies, as is the case with wheat, whose harvesting season does not cover over three months. There is therefore in the United States a comparatively small supply of sugar at the present time. If an enemy nation could get control of Cuba and Hawaii, the United States would, in a comparatively few weeks, be without sugar. Private advices from Cuba indicate that the revolutionists have destroyed millions of dollars worth of sugar, and I am informed that this is the cause of the recent advance in the price of sugar.

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While I do not assume that our enemies are going to get control of these sugar-producing islands, the possible contingency I feel to be one of the most important questions before the United States at the present moment. It would obviously be difficult to store sugar, either through public or private agencies, without seriously disturbing trade. Nevertheless, the matter should be very carefully considered, and the state should be advised by importers who understand the sugar trade, just how far it is possible to go in providing against the contingency just suggested. While a serious shortage of sugar is a calamity which might temporarily befall this nation, it is a condition which could not be made permanent. To begin with we can produce indefinitely quantities of glucose from Indian corn. Further, with sugar at 10 cents per pound, vast acreages in the United States could and would be profitably used in raising sugar beets if it were believed that high prices would continue. Moreover, sweet sorghum is a crop that can be raised extensively and with ease. The culture of sweet sorghum can be much more easily extended than the culture of sugar beets. More than thirty years ago the technical methods of producing sugar from sorghum were definitely worked out, but they cannot be used profitably with sugar at 5 cents per pound. The cost of producing sugar from sweet sorghum at the present time is determinable. If it were known in April that there was an emergency that required it, it would be possible to plant sorghum in May in unlimited areas, and to build factories while the crop was growing. If, however, the emergency were not perceived until September, it would take fourteen months, instead of seven months, to deliver the sugar. In other words, unlimited quantities of sugar could be produced in this country if it became necessary, but we shall doubtless prefer to secure the bulk of our sugar from neighboring islands at 5 cents or 6 cents per pound, than to produce it from sweet sorghum or even from sugar beets at 10 cents per pound.

While I expect that it will never become necessary, the condition concerning sugar in the United States and that concerning wheat in California make it desirable, if it is legally possible, to pass a law giving the Governor of California power to take over and store food products when he may deem it necessary, and to issue certificates of sale, bearing 4 per cent interest, against these products, the time of redeeming the certificates of sale being at the option of the state.

This is not greatly different in effect from the practice of grain elevators in the central west, which issue certificates of storage that the farmer may discount at the bank.

It is possible that certain contingencies may arise that would

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make the power suggested to be granted the Governor of great value, and if the contingency never arose, the passage of the law could do no harm.

No admonition is necessary to the farmer to grow materials so long as he understands which are likely in the long run to bring him the best returns for his labor. It may be possible, however, for the farmer to misjudge the future needs and demands. In fact, it is not possible for any human being to judge accurately. Anyone who could do so successfully might easily become many times a millionaire. This idea may be illustrated by the insistent demand for the planting of potatoes and other vegetables. Most of the effective effort for the production of food for human consumption during the season of 1917 in California has long ago been discounted. What the public does not understand, and what perhaps many farmers do not realize is that as an emergency measure what is needed is the extension of forage crops as food for domestic animals. Such crops as milo, feterita, Egyptian corn, sweet sorghum, and Sudan grass should be extensively planted. They are crops in which a minimum of effort gives a maximum of result. There has not been a season in years, I am credibly informed, in which cattle and sheep in California have come through the winter in such poor condition as in the present one. Scarcity of winter food, and the cold, backward spring, entailing scanty pastures, are among the chief causes.

Already the College of Agriculture has publicly urged upon the farmers the consideration of these crops above mentioned. Quite by accident, as far as this emergency is concerned, the College of Agriculture has issued an exhaustive bulletin on Sudan grass, which is now being distributed, and which will reach over 30,000 persons. It has in hand manuscripts on grain sorghums and on sugar beets, which will soon be distributed.

Land that is under irrigation will without doubt be fully used. It may be desirable, however, to urge upon farmers the interplanting of beans and grain sorghums in young irrigated orchards. It is possible that the trees may be slightly affected by this procedure, but the emergency warrants it, even from the standpoint of the farmer's personal interest.

In order to farm successfully great areas of California land not under irrigation, it requires looking ahead two years. For this season the die is largely cast, and to some extent even for the year to follow. Every possible preparation should be made to put suitable unoccupied land into condition to grow crops next year, and the year after. Inasmuch as in many cases two years must elapse

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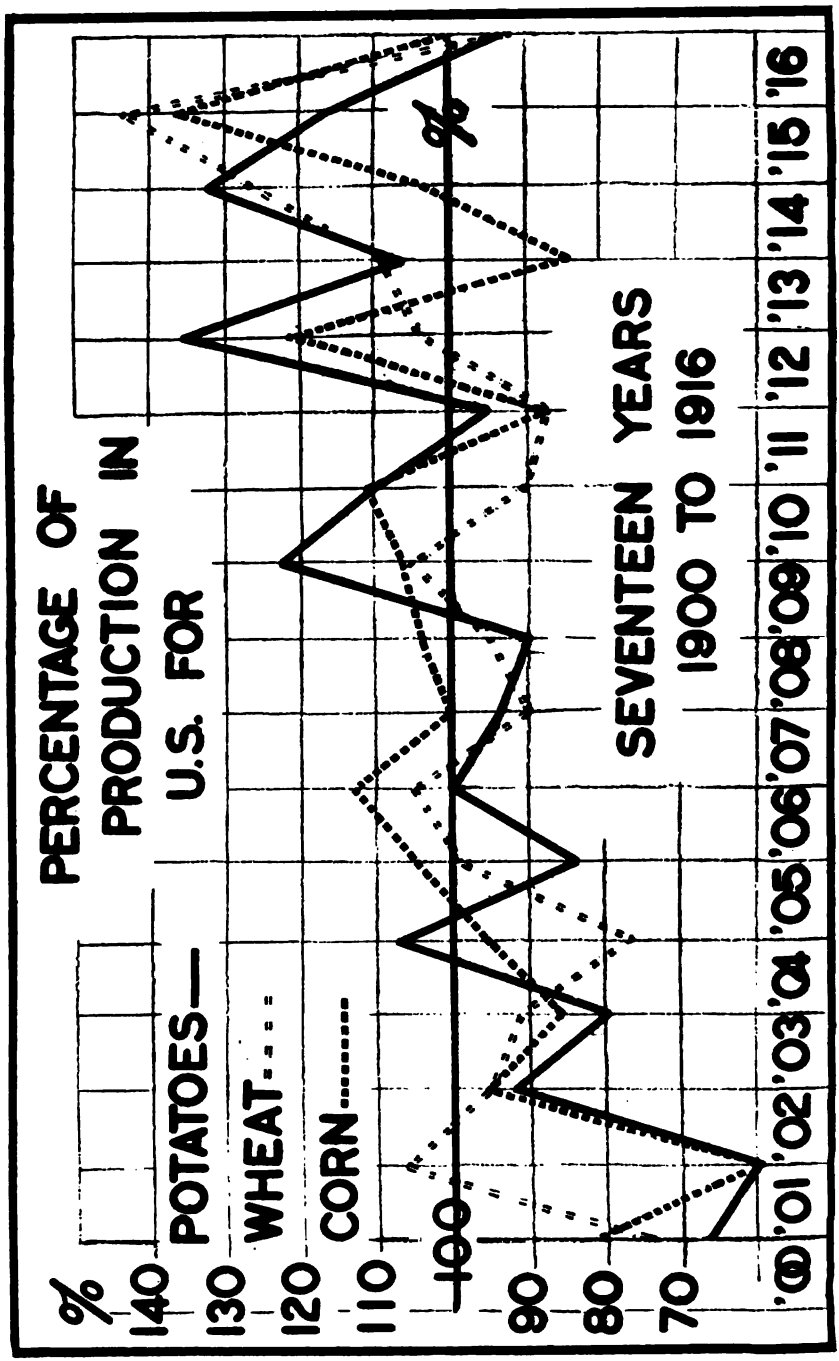

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before crops can be obtained, I recommend to the Committee that it give consideration to the possibility of financing the farmer who must wait two or more years for his returns.

Keeping in mind that farm products during the next three years only are under consideration, the chief factors in the quantity produced are the weather and the labor supply. A glance at the chart is sufficient to emphasize the influence of weather conditions. Nevertheless, the labor situation may become acute. As an illustration, the Navy Yard at Mare Island recently advertised for an unlimited supply of labor at $2.50 per day. The only requirement was the ability to lift a 150-pound sack. This immediately sets a price on unskilled labor in California. This Committee should carefully consider whether it would be justified in requesting that farmers and farm laborers do not enlist for military service, just as it is understood that England has urged her skilled artisans to work in the munition factories rather than go to the trenches. There are other aspects of the labor problem which this Committee may wish to consider, as, for example, the month or months of the peak load of labor for any community; the possible use of soldiers while in training to meet such peak load; the possible organization of bands of laborers for the same or similar purposes, and the better organization of labor-saving machinery, such as, for example, the itinerant rental of State-owned tractors and attendant machinery.

I am not advising that these things be done, but I am suggesting that they are very pertinent subjects for the consideration of your Committee.

Without stopping to summarize the fundamentals hastily and crudely outlined, I desire in closing to state the service which the Department of Agriculture of the University of California is in a position to render immediately, if the Committee considers it desirable. By co-operating with the county organizations which it is understood the State Council of Defense purposes to create, or without such organizations, it would be possible to hold meetings in each county in the State, where public hearings could be held as to existing conditions, and at which any recommendations which this Committee may wish to formulate can be discussed with the farmers in attendance. The importance of such hearings will obviously depend upon the character and concreteness of the recommendations which the Committee wishes to make at this time, and the character of the information it desires to secure as the basis for future action. The Department of Agriculture has the machinery by which this can be

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accomplished in every county in the State in twelve days. If it is worth doing, the sooner it is done the better.

I presume that the deliberations of this Committee will fall into three categories:

1. What advice the Committee desires at this time to give to the public.

2. What legislation it desires to suggest to the State Council of Defense.

3. What further inquiries it desires to make or have made, as the basis for future action.

If in any of these matters, or in any other way the 165 officers of the Department of Agriculture of the University of California can aid your Committee they are entirely at your disposal.

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STAPLE FOODS FOR AN AVERAGE FAMILY OF FIVE PERSONS

Food materials	Pounds per family per year		Price per pound	Total expended per family	
	Min.	Max.		Min.	Max.
Milk	1368	1746	$0.05	$68.40	$87.30
Butter	85	145	.35	29.75	50.75
Meat	684	970	.20	136.80	194.00
Oil and fat	85	145	.20	17.00	29.00
Eggs	114	291	.25	28.50	72.75
Beans	21	24	.10	2.10	2.40
Flour	456	485	.05	22.80	24.25
Cereals	171	194	.07	12.00	13.58
Macaroni	28	28	.10	2.80	2.80
Rice	42	48	.05	2.10	2.40
Potatoes	570	776	.05	28.50	38.80
Green vegetables	684	873	.04	27.36	34.92
Fruits	571	970	.05	28.50	48.50
Sugar	233	340	.08	19.00	27.20
Tea and coffee	34	73	.30	10.20	21.90
Sundries	.....	.....	....	.....	.....
Totals				$435.81	$650.55
Per person per day				$0.238	$0.356

NOTES.—*Sundries* include such articles as chocolate, corn starch, baking powder, sago, gelatine, flavorings, spices, and all dainties and extras. The family consists of father and mother, son 16, daughters 10 years and 3 years respectively.

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SMALL FRUIT CULTURE IN CALIFORNIA

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Instructor in Pomology

INTRODUCTION

Small fruits, especially the brambles or fruits of the raspberry and blackberry type, are grown in nearly all parts of California. The plantings vary from the few bushes or plants cultivated for home use, to plantations in which several hundred acres may be devoted to the production of enough berries to supply both local and distant markets with fresh fruit and to allow a considerable portion of the surplus to be canned. Nearly all of the different kinds of small fruits have been found to be adapted to California soil and climatic conditions and, although some of the members of this class of fruits cannot be grown successfully on a commercial scale in the hot, dry sections of the state, with judicious handling they may often be made to thrive in the home garden. The home garden can be made to supply fresh berries of various kinds for the table throughout a long season.

The small fruit industry presents a number of problems not encountered in the production of tree fruits, many of which must be solved by more precise methods than those so largely used by deciduous fruit-growers. Berries are a soft, perishable product and must be handled accordingly; the bushes are short-lived, shallow-rooted, and subject to injury by drouth. On the other hand, if properly managed, the small fruit garden or the commercial berry plantation can be made to yield large profits, often as soon as a year or two after planting. To accomplish the best results, however, painstaking attention must be paid to all the minor details connected with the production and marketing of the crop. Broadly speaking, this class of fruits demands the personal attention of the owner or proprietor, and very often the greatest success is obtained when prac-

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tically all the work can be done by the members of the immediate family.

There are a number of general factors involved in the success or failure of a berry plantation, the most important of which are the following: Accessibility to market; labor; location; water-supply; care or management of the planting. Other factors, such as insects and diseases, pruning methods and choice of varieties, while important, are more nearly under the control of the grower.

Fig. 1.—Boy from orphanage picking loganberries. The summer vacation renders this kind of labor available when needed. (Photograph by permission U. S. D. A.)

Because the crop is a very perishable one and often ripens within a comparatively short season, the small fruit plantation must have a market that may be reached quickly. The market should be either within easy driving distance of the plantation or situated on a railroad, in which case the shipping station should be near to the plantation. Jolting over rough country roads in a wagon or auto-truck during the hot portion of the day often causes berries, especially if over-ripe, to become mushy and to deteriorate very quickly. The market should be large enough to use the fruit brought to it for disposal without danger of the supply exceeding the demand, as other-

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wise the price received for the product will be reduced below the point at which this fruit can be produced profitably. In case the near-by markets cannot use the crop, other outlets such as more distant markets or a cannery must be sought.

Picking berries is slow, tedious work and the result of a day's labor is often not more than a crate or two. The entire patch must be picked every day or at least every other day, at the height of the season, to insure berries of a uniform degree of ripeness. The oper-

Fig. 2.—Class at University Farm, Davis, planting strawberries on raised beds.

ation requires a great deal of stooping and reaching for the fruit near the ground, and with the brambles, the picker is often considerably scratched by the prickers on the plant during the course of a day's work. Berries are usually picked on a piece-work basis and a comparatively low price is paid for each quart or crate picked. For these reasons, the largest part of the work is done by women and children (fig. 1) or such itinerant labor as may be found during the season. Location near some fairly large city in a district where such help can be obtained is absolutely essential.

The choice of the site for the plantation is very important. A region subject to late spring frosts must be avoided. Bottom lands or swales into which cold air drains from the higher surrounding

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elevations are hazardous because of the danger of the buds or flowers being frozen. The site should be chosen to allow the heavy, cold, air to drain away from the plantation to lower levels. The aspect of the plantation may influence the season of ripening to a considerable extent. With small fruits a warm exposure may cause the fruit to ripen several days or a week earlier than the same variety planted a few hundred yards away on a site which faces in another direction. Earliness is usually desirable with small fruits as it is the early fruits that command the best prices.

Small fruits belong to a shallow-rooted class of plants. This is especially true of the strawberry, which seldom sends its roots below fourteen or sixteen inches. Plants of this type, with a few exceptions, are not adapted to sending roots to a great depth for moisture, hence the available water in the soil, whether supplied by rains or by irrigation, must be carefully investigated before planting. There must be sufficient moisture in the soil during the growing season to keep the plants green and vigorous. At no time should they be allowed to wilt or show signs of drouth. Lack of moisture is shown directly by weakness of the new growth and indirectly by the subsequent smaller crops during the succeeding years. With a few notable exceptions, the small-fruit sections of California are in irrigated districts. In sections where irrigation cannot be practiced, the soil moisture must be conserved by frequent shallow cultivations.[1]

To a great extent the success of a small-fruit plantation depends upon the care given it. The operations necessary to the production of a crop of this class of fruits require more hand labor of an irksome nature than do those necessary for the tree fruits. The plants are small and set close together, which necessitates much hand hoeing in place of the horse cultivation with suffices with tree fruits. Weeds must be kept down, as they draw upon the soil moisture in the area occupied by the roots of the plants under cultivation. Operations of planting, pruning, and trellising require a great deal of hand labor because of the low-growing nature of the plants, and because of the large number of plants that are planted per acre. Tree fruits often produce fairly satisfactory crops when grown under the more or less hap-hazard methods so commonly followed by deciduous fruit growers, and the evil effects of the lack of pruning or spraying may not become apparent for a few years; but with small fruits this is not the case. A berry plantation neglected for one season, as a rule, produces a much smaller crop the following year. On the other hand,

[1] See "Irrigation Practice in Growing Small Fruits in California," by Wells A. Hutchins, Cal. Agr. Exp. Sta. Cir. no. 154.

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this type of fruits responds quickly and readily to proper pruning, thorough cultivation and careful irrigation.

SOILS

The brambles, i.e., blackberries, raspberries, dewberries, and loganberries, are adapted to being grown on a wide range of soils. Success with this class of fruits depends more on the skill of the individual grower and other factors, such as site, suitable labor supply and acces-

Fig. 3.—Strawberry plant, variety, Oregon, grown under level culture system.

sibility to market, than to the choice of any particular soil. However, most of the successful plantings are found on soils ranging from sandy loam to clay loam types. As these plants are deep-rooted the depth of the soil must be given special consideration. Strawberries thrive on soils of the clay loam type, but are also found growing with considerable success on sandy loams and on the loose gravelly soils of some of the lower foothill districts. In general, the lighter types of soils are easier to handle, but the fruit is often small if not given proper cultivation and irrigation, while, on the other hand, the heavier types of soils, though harder to cultivate, produce large crops of fruit. Currants and gooseberries are two fruits generally adapted to the

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heavier soils used for the growing of fruit, and often grow well on soil which is wet for a considerable portion of the year.

For all small fruits, it is desirable to have the soil well supplied with humus, for ease in cultivation and conservation of moisture. This material is best supplied by plowing under cover crops or barnyard manure.

PROPAGATION

One of the factors that have an important effect on success in growing small fruits is the ease and readiness with which a new planting may be started. New plants may be obtained from older plantations with but little trouble, or they may be purchased from a nursery at comparatively low prices. This factor is of special significance to the man of limited means just starting to grow fruit. Many of the brambles propagate naturally and abundantly of their own accord, while strawberries start annually more new plants than should be allowed to grow if best results are to be obtained from the plantation. Currants and gooseberries root readily from cuttings. The result is that new plantings may be set out, using older plantings already in existence as a source of supply, with no cost except for the labor of collecting and setting out new plants.

Blackberries and red raspberries may be propagated either by root cuttings or by suckers. These suckers, which appear wherever a root has been cut or injured, may be dug up and used as new plants, care being taken to secure a large portion of the roots. This method of securing new plants is very commonly used in this state and has proved to be satisfactory in every respect. The method of securing plants by root cuttings, which is the usual procedure in nurseries, is to dig up a number of old plants and cut the roots into short pieces, three inches or less in length. These roots are sown in rows in carefully prepared nursery soil. If not allowed to dry out and if given careful cultivation, they produce plants large enough to set out in one year from the time of making the cuttings.

Dewberries, loganberries (including the Phenomenal) and the black raspberries are usually propagated by tip layering. The method of obtaining plants in this way is to cover the end of the canes with a shovelful of earth, during the latter part of the summer. The portion of the shoot which is covered sends down roots from the nodes, and forms a plant which is ready for planting the following spring.

New plants of currants and gooseberries are usually obtained from cuttings. These fruits may also be propagated by mound layering. Cuttings are made about seven to ten inches long from matured or ripened one-year-old wood. They may be cut at any time during the dormant season, and set out immediately in rows or stored in moist sand in a cellar or other cool storage place until spring. The cuttings are planted in nursery rows with one or two buds above the surface, care being exercised to see that the soil is firmly pressed around the portion which is buried. The resulting plants are grown in the nursery for one or two

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years. It is the practice in some sections of California to set these cuttings out in permanent form, instead of growing plants in the nursery row for a year.

Strawberries propagate by means of runners or offsets. During the growing season, the old established strawberry plants send out in all directions slender stems eight to fourteen or sixteen inches long. Each alternate node, if in contact with the ground, takes root and forms a new plant. The roots become established in the ground, and later, the slender stem connecting the old plant and the young, dies, leaving the new plants independent and in turn ready to send out runners. These young plants, before they have produced fruit, are the most desirable ones for planting in new plantations. The ease of gathering new

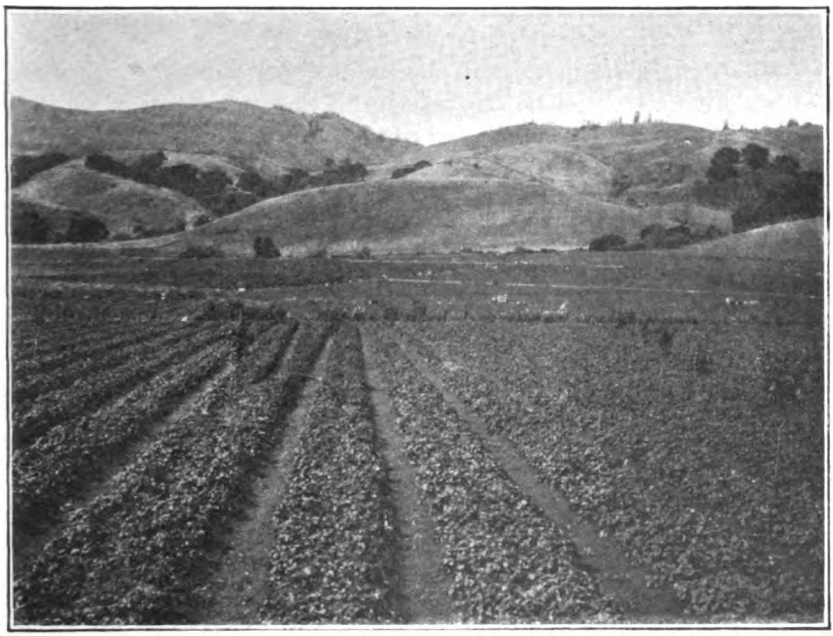

Fig. 4.—Method of growing strawberries on raised beds. Strawberries are often grown as an intercrop in orchards until the trees come into bearing.

plants should not lead to carelessness in the matter of selecting the best stock available, and certain precautions should be observed in collecting new plants from old plantations. Plants from diseased or insect-infested areas should be discarded and only clean, healthy ones chosen. Carelessness in the choice of plants often leads to the introduction of diseases and insects into sections that may previously have been clean.

PLANTING

The brambles and the bush fruits are planted so they may be easily cultivated in one or two directions. They are planted in hills or rows to conform to the growth of the plant and the nature of the

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site upon which they are set. Strawberries are usually set in rows and cultivated in one direction only, relying on the use of the hand hoe for stirring the soil between the plants in the row. The planting distance is governed by the ultimate size of the plants and convenience in cultivating and picking. Whenever practicable, these fruits should be planted early in the season, preferably not later than February. A larger number of plants survive when planted early than is the case where the planting is delayed until March or April. Gooseberries and currants start to grow very early in the season and, hence, should be planted in the autumn. Strawberries are planted in the spring months or during the fall and early winter.

The preparation of the soil for the new berry plantations should be as thorough as possible. On account of the shallowness of the feeding roots of small fruits, the effort expended in preparing the soil before planting will be repaid by the vigor and thrift of the young plants. The soil should be plowed deeply in time to allow the weeds or cover crops to decompose before the plants are set out, and the soil should be as fine and friable as it is possible to make it by frequent harrowings. A mellow soil, free from lumps, enables the young plants to become established quickly, and a larger percentage live through the first year than is the case when the soil is carelessly prepared.

Blackberries should be set out during February or March in order to receive the benefit of the late rains. The plants ordinarily require but little care in planting. The long, slender roots are cut off, and the plants are set at the same depth they have been grown in the nursery. A hole is opened by a spade, the roots are spread out in a fan shape and the earth is crowded firmly around them so that all portions of the root-system come into immediate contact with the soil. The old stem is usually left as a marker or guide in cultivating before the new shoots, which usually appear from the crown, can be seen. Instead of opening each hole with a spade or shovel, a furrow may be plowed along the row and the plants placed along the landside and handled in much the same way as that just described. Blackberries of an upright-growing habit such as the Lawton are usually planted in rows six to eight feet apart with the plants four to six feet apart in the rows. If planted in hills, they are usually set six to eight feet apart each way. The trailing varieties, like the Mammoth, are planted in rows about eight feet apart and eight to sixteen feet apart in the rows. Loganberries, Phenomenal loganberries, and dewberries are trailing in habit and are spaced about the same as the Mammoth.

Raspberries.—No definite standard planting distance can be set for raspberries. The distances vary according to the variety and the district where grown. If planted in hills, the plants are from three to six feet apart each way. If planted in rows, the rows are ordinarily six to eight feet apart and the rows themselves may be a solid mass of plants or may have the separate plants from one and one-half to four or six feet apart. Ordinarily the black raspberry requires more room than do the red varieties because it is more spreading in nature.

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Currants and Gooseberries.—When planted in rows, currants and gooseberries are planted two and one-half to five feet apart in the rows and the rows are five to six feet apart. In hills, the plants are set on the square system, five or six feet apart each way.

Strawberries.—Strawberries are planted according to different methods that are influenced by the irrigation practice in a given district. The necessity for frequent irrigation has led to the adoption of a number of cultural methods that will be discussed briefly in the following paragraphs. As a rule, strawberries in California are grown in rows rather than in hills, and greater acreages are grown in "raised beds" than are grown in "level culture."

Fig. 5.—Strawberries being grown as an intercrop in a young plum orchard, under level culture system.

The raised bed (fig. 2) differs from level culture in that the plants are grown on a wide row slightly raised above the intervening spaces which are used for irrigating, cultivating, and as paths for the pickers to walk upon. The sunken spaces in the raised-bed system are permanent during the continuation of the plantation, while the irrigation furrows in the level-culture system are made for each irrigation or at the beginning of each season. The width of the beds and the furrows vary greatly in the different sections. The type of soil influences the width of the bed; thus, if lateral percolation is rapid and the entire bed is moistened quickly, the width of the bed may be greater than in soils where the water soaks in slowly. The common width of the raised bed and its adjacent furrow is four or five feet; the bed itself occupying considerably more than half of this width. The beds are raised from three to six inches above the furrows and are 200 to 300 feet long.

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In sections where the beds are narrow, plants are set out in a single row in the center of the bed from eight or ten inches to twenty-four inches apart, depending on the rate at which the new runners are produced and the number of plants available at the time of planting. Runners or offsets are allowed to take root in the row itself and not to spread laterally, the aim being to maintain the width of the row at ten or twelve inches. Runners spreading laterally are either cut off or moved to the center of the row. Where the beds are wider and the wide "matted row," as it is called, is desired, the plants are set out in a double row (fig. 2), the rows being eighteen to twenty-four inches apart, and four to eight inches from the edge of the bed. The plants are allowed to spread toward the edge of the bed and toward the center, forming a solid mat of plants. A variation of the matted-row system is to provide a rather narrow but deep furrow for irrigation extending for the full length of the row in the center of the bed. The paths, in the latter case, are not sunk below the beds, but maintained on the same level. When level culture (fig. 3) is practiced, the plants are set out ten to fourteen or sixteen inches apart in the row, and maintained as separate hills, or allowed to form solid rows. Irrigation water is applied by shallow furrows made as close to the rows of plants as possible, whenever needed.

The raised beds can be irrigated more conveniently than can the level-culture plantings, as the ditches are permanent and are not destroyed by cultivation. Frequently, however, water is applied without any attempt to cultivate, and the result is a hard-baked path between the rows. The level-culture system is adapted to thoroughness in cultivation and stirring of the soil between the plants.

Strawberries require greater care in planting than do most of the small fruits. Only young plants, having light-colored roots, should be used; the older plants having dark-brown roots should be discarded. The plants must not be allowed to dry out during the planting operations, but should preferably be wrapped in wet burlap or kept in pails of water. The outside whorl of leaves should be removed when the plant is set out, leaving only one or two of the small center leaves. The plant must be set firmly at the same depth at which it had been growing. If set too high, or if the soil is not sufficiently firmed, the young plants will dry out and die; and if set too low and the crown of the plant is covered with moist soil, the plant quickly rots.

CULTIVATION

Shallow cultivation should be the rule with all small fruits. The feeding roots are comparatively near to the surface and are destroyed by deep cultivation. With the brambles, a great many roots are broken by deep cultivation, and this practice results in producing a large number of suckers in the middle of the row which must be cut out with a hoe. In other cases, an entire plant is often pulled out by catching the cultivator under one of the main roots. The land should be plowed in the spring, as shallow as possible and still turn over a clean furrow and completely cover the trash or cover crop that may be on the ground. The plowing should be followed by frequent shallow stirring, preferably with a light, fine-toothed implement.

Blackberries, Loganberries, Currants, and Gooseberries may be plowed deeper toward the middle of the row and shallower when close to the plants. If the

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furrows are thrown away from the row it is much easier to hoe out any weeds that may be growing in the row itself, while, on the other hand, if the furrow is thrown toward the row, these weeds are covered up, only to appear later in the season. Unevenness, due to leaving the back-furrow or dead furrow in the middle of the row is easily remedied by a few cultivations. Another plan, adopted by many growers, is to harrow or disc the plantation instead of plowing. This plan works satisfactorily if done before the cover crop has reached a size where it can only be covered by plowing. If the rows are close together, the plan of cultivating or discing to break up the soil is usually followed if the plantation is to be continued through the following year and not removed to

Fig. 6.—Wires attached to short cross-bars are used to support heavy trailing varieties of blackberries. (Photograph by permission U. S. D. A.)

make room for another crop. Clean cultivation should be practiced throughout the season until the cover crops are sown or the fall rains begin.

Strawberries are usually grown on permanent beds raised slightly above the intervening spaces (fig. 4). The method of starting spring cultivation in this case is usually to break the ground with a one-horse cultivator. If grown under the level culture system (fig. 5), one or two shallow furrows may be plowed between the rows, turning the furrows toward the middle. More often, however, the ground is broken with a single cultivator. In case the strawberries are mulched with straw or other mulching material, no cultivation is attempted. The spaces between the plants not covered by them should be hoed, to break up the crust and to keep down the weeds. Cultivations should continue throughout the season to keep the plants in thrifty condition.

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PRUNING

The pruning of small fruits cannot be neglected for even a single season. Strawberries, which do not produce hard or woody stems cannot be considered as coming under this statement, their fruitfulness in a measure depending upon the number of runners allowed to be produced from the old plants; hence, they need regular attention as much as do the bush fruits. The brambles, which include all small fruits in this circular with the exception of currants, gooseberries and strawberries, produce fruit usually but once on a cane of one season's growth. There are, however, a few varieties of this class of fruits like the Himalaya and Evergreen which have perennial canes. The canes which are necessary for the bearing of the crops are produced during one season, flower and bear fruit during the next, and must then be removed. As soon as they have borne a crop of fruit their usefulness ends, and they usually die before winter. The aim of the grower in pruning should be to accomplish two things: First, to remove the old canes which are of no more value to the plant; and second, to provide a supply of new shoots for bearing fruit the following season. The care of strawberries and the pruning of currants and gooseberries are different from the general directions given above and will be discussed in the paragraphs devoted to these fruits.

Blackberries.—Blackberries are pruned in such a way that they may be tied to wire trellises (fig. 6), tied to upright stakes (fig. 7), or trained to grow upright without support of any kind. The varieties which trail, or produce long runners that naturally lie on the ground, are trained to wires stretched on posts, and the stronger upright-growing varieties are tied to stakes or pruned short so that they are able to support their own weight. The length of the canes which are left to produce the following season's crop varies considerably with the variety and with the practice found to give the best results in different sections. Strong-growing varieties like the Lawton are usually pruned back to three or four feet. Trailing varieties like the Mammoth are cut back leaving eight to fourteen or sixteen feet, depending on how far apart the plants are set in the row. It is a good practice to tip back or cut off the ends of the growing shoots during the summer as soon as they have reached the desired length. This tipping back tends to induce lateral branches to grow and thus increases the fruit-bearing area of the plant.

New canes to take the place of the old ones removed after fruiting come up as suckers around the crown of the plant. More of these suckers are produced than should be allowed to grow. For most varieties from four to seven new canes should be left to each hill and the remainder cut off close to the ground. The healthy and vigorous canes should be left and the small or inferior ones removed. This pruning should be done during the winter season.

Trailing varieties are trained to one or two wire trellises. When one wire is used, it is stretched along stakes in the row at a height of two and one-half or

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three feet above the ground, and the canes are fastened to it by winding them around the wire or tying them to it (fig. 8). The new canes which grow during the season are allowed to lie on the ground under the row during the growing season. During the winter pruning the old canes are cut and pulled off the wire and the new canes are brought up and tied in their place. Sometimes two wires are used, the lower one is two to three feet from the ground and the upper wire one and one-half to two and one-half feet above the lower one. The young canes may be trained to the upper wire, and the bearing canes to the lower, or the practice may be reversed. Loganberries (including the Phenomenal variety), and dewberries are pruned and trained in the same manner as trailing

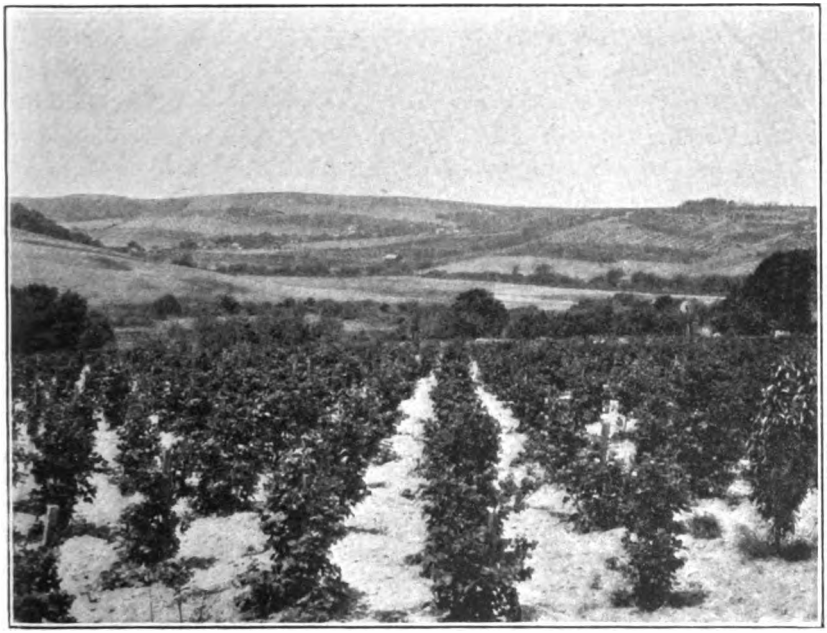

Fig. 7.—Upright varieties of blackberries are usually tied to stakes. (Photograph by permission U. S. D. A.)

blackberries. The general practice in this state has been to train these varieties on a single wire, extending the canes along the wire either in one or both directions from the crown of the plant.

Raspberries.—Both the red and the black varieties of raspberries are for the most part trained to stand alone. In some cases, when varieties are drooping in nature or a rank, heavy growth is produced, posts are set along the row and short cross-arms eighteen or twenty inches in length are nailed at a convenient distance from the ground, usually two and one-half to three and one-half feet. Wires are stretched from post to post at the end of these cross-arms. The plants are pruned so as to grow up between these wires and are supported by them and, as a rule, no additional tying is considered necessary. Blackberries may also be trained to this system (fig. 9). By means of short cross-pieces fastened to

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the wires, a number of different methods of training may be devised to suit local conditions.

Raspberries produce their fruit in the same manner as do the blackberries, hence the old canes must be removed after fruiting. The plants are thinned to three to six or seven canes to the hill and cut off about three to four feet above the ground, depending upon the nature of the growth made by the plant and the training system followed. Weak-growing varieties without supports must be cut back more heavily than the more sturdy sorts. Red raspberries produce large numbers of suckers which spring up from the roots, and, unless it is desired to have a more or less solid row (fig. 10), these suckers must be grubbed out with a hoe, and the plants maintained in single units.

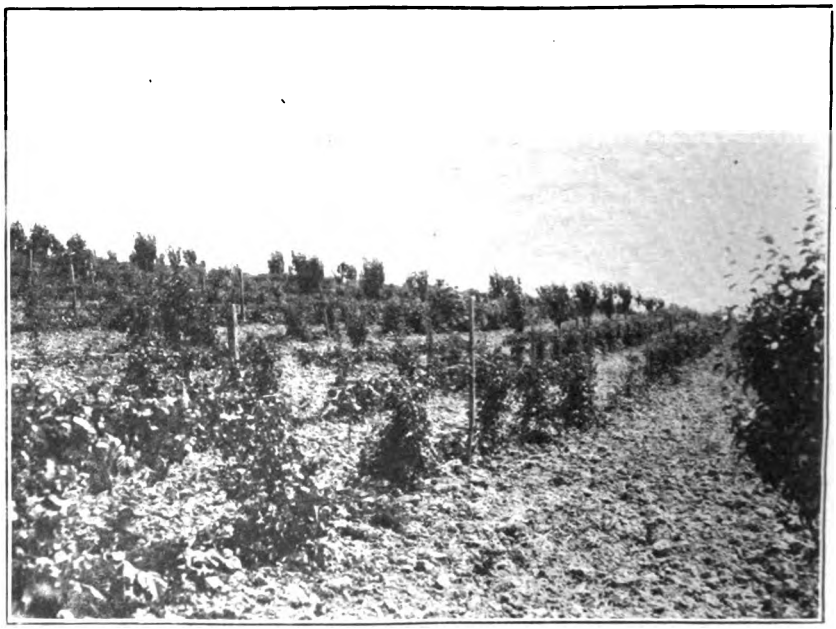

Fig. 8.—Loganberries tied to a single wire trellis. The young shoots are allowed to grow on the ground under the row during the first season.

Currants and Gooseberries.—These fruits must be treated in an entirely different manner from that described for the brambles. The growing habit and method of bearing fruit of these two kinds of berries must be carefully studied in order to prune them correctly. The bushes of the currant and gooseberry are more compact in form and are treated more like a tree fruit than are the brambles. New wood is produced both by the branching of existing limbs and by suckers which come up from the root. These suckers, however, come up near the crown of the plant, and not promiscuously from the roots as in the case of some of the raspberries. The larger portion of the fruit is borne from short spurs on the two and three-year-old wood, a smaller amount being produced on the four and five-year-old wood.

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DURATION OF PLANTATION

Small fruits come into bearing early, reach their maximum production in from three to give years, and then begin to decline. Very few of the bush fruits remain profitable after eight or ten years, while strawberry plantations should be removed after the fourth or fifth season. The intense cultivation given this class of fruits, as a rule, quickly exhausts the humus in the soil, leaving it in a poor physical condition. In addition to the foregoing reason, the presence of one or

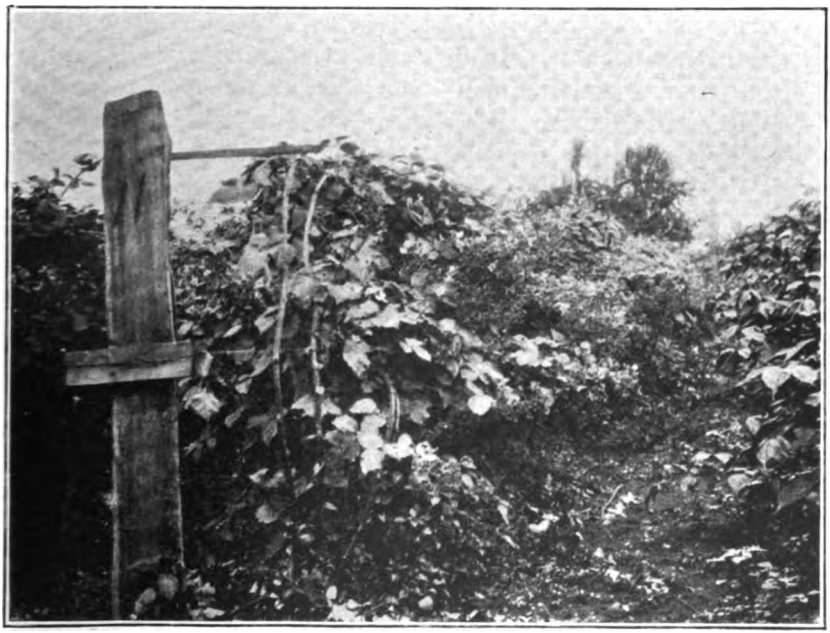

Fig. 9.—Trailing varieties of blackberries are trained to grow on wire trellises. (Photograph by permission U. S. D. A.)

more diseases in a field often makes it advisable to plow up and burn all of the old plants and start a new planting rather than to attempt to eradicate the trouble in the existing plantation.

Blackberries and raspberries should produce a few berries the second season after planting, reach their maximum production in from three to five years, and should be removed in from seven to ten years, according to the character of the soil and the care given the plants. Loganberries often produce fairly heavy crops the second season after planting and remain profitable a number of years. Currants and gooseberries ordinarily do not produce crops until the third year, are at their best from the third to the sixth year, and should be removed

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not later than the ninth or tenth year. Strawberries normally produce their largest crops the second year, and should be removed after the fourth or fifth season.

BERRIES AS INTERCROPS

Because of the fact that berries provide a source of immediate income and occupy the soil for a limited length of time, they are used considerably as intercrops in orchards (figs. 4, 5, 8). If properly managed, no injury to the trees results, and the grower has a source of revenue until the trees come into bearing. The chief danger from using berries as an intercrop in young orchards is that the welfare of the permanent planting may be forgotten in the effort to produce one more crop after the bushes should be removed. Examples of poorly pruned, stunted trees are to be found in every section where berries have been used as intercrops. The care of the intercrop of berries should not interfere with the cultivation, pruning, spraying, or general care of the trees; hence, where it is impossible to care properly for both the berries and the trees, the trees, rather than the temporary berry plants, should be given the proper attention.

FERTILIZERS

Berries, being shallow-rooted, remove a great quantity of plant food from the surface layers of the soil, and this drain must be replenished by the addition of materials containing the elements essential to plant growth. One of the best fertilizers that can be used for this class of fruits is an annual application of well-rotted barnyard manure. Complete commercial fertilizers, or those which contain potash, phosphoric acid and nitrogen, can also be used successfully, although caution is advised in the application of any commercial product which contains a high percentage of quickly available nitrogen, because of the fact that this element often stimulates leaf production and fruit-bearing is lessened. The use of nitrogen is said to produce soft fruit that does not stand shipping. This element, however, may be added to the soil by the use of leguminous cover crops, such as vetch or bur clover, without as much danger of stimulating the vegetative vigor of the canes, with the added physical benefit of the organic matter which is incorporated in the soil at the same time.

INSECTS AND DISEASES

Small fruits are not seriously troubled by insects or diseases. The heavy annual pruning to which they are all subjected (with the

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exception of the strawberry), in which the old wood and such new shoots that may show signs of disease or insect injury are removed, serves to hold these troubles in check. The comparatively frequent removal of the plantation also serves to prevent the permanent infestation of a given piece of ground. In many cases, it is cheaper to pull out the old plants and reset with healthy ones in a new location than it is to combat insects or fungous diseases by spraying or by other preventive measures.

Brambles.—The most serious disease of the brambles with which the grower must contend, is the crown-gall or root-knot. This is a bacterial disease forming

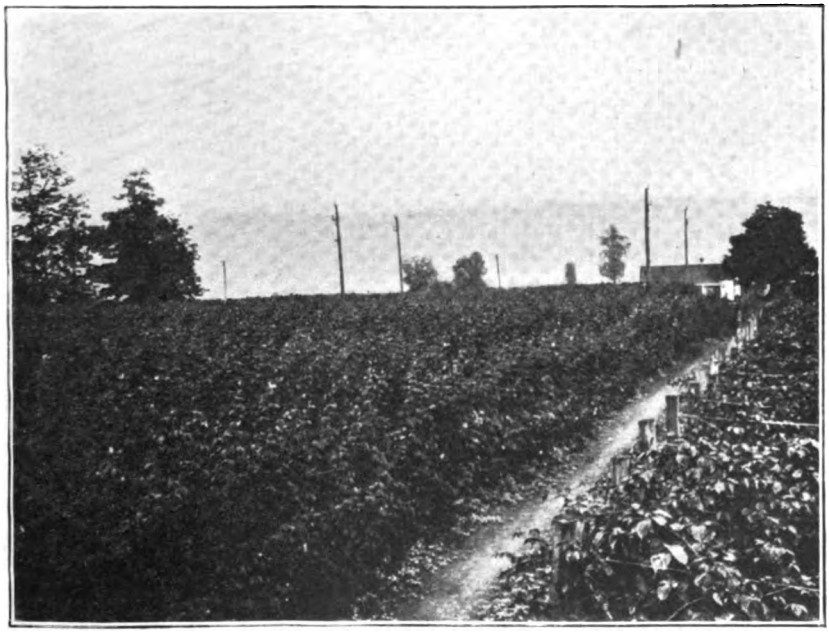

Fig. 10.—Raspberries are often grown in solid rows. The plants are either pruned to grow upright without support, or are fastened to wires as shown in the illustration. (Photograph by permission U. S. D. A.)

a warty growth on the roots and ultimately causing the death of the plants. This disease can only be held in check by planting clean stock when setting out new plantations and by removing and burning old plants which are infected in the older plantings. During some seasons the leaves of nearly all varieties of blackberries and raspberries are affected with blackberry rust, which forms reddish pustules on the under surface, or with leaf-spot, which forms small brownish spots which later drop out. The remedy for both diseases is to cut out the infected shoots or to spray with Bordeaux mixture when the disease is first noticed.

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Currants and Gooseberries.—Currants and gooseberries are troubled with mildew, which forms a whitish powdery growth on the new leaves and shoots, reducing the vigor of the plantings and ultimately affecting the size of the crop. This disease is usually controlled by dusting the plants several times during the early part of the season with flowers of sulphur, or by spraying with

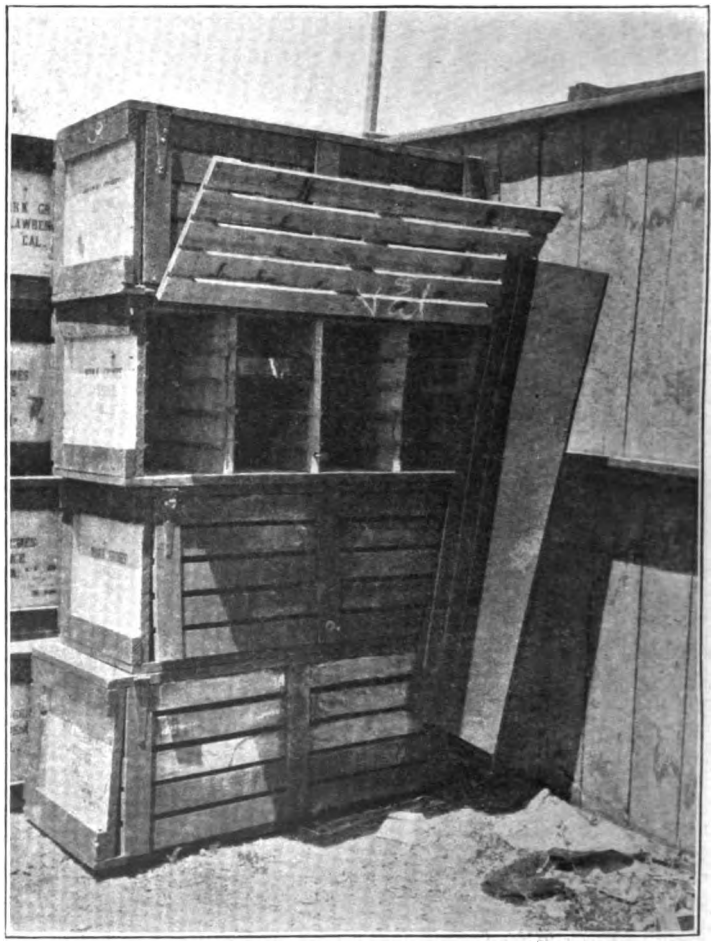

Fig. 11.—The twenty-drawer chest used in California for local shipments of small fruits. Each drawer holds two large, or six small cups. (See fig. 12.)

Bordeaux mixture as soon as the mildew appears. These two plants are also injured by the work of the currant borer. This insect works in the heart-wood of the branches or stem of the plant, which it either kills or injures to such an extent that these parts break down under the weight of the crop of fruit. The only remedy is to watch carefully for its work and remove all infested parts when pruning.

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Strawberries.—The most serious disease of strawberries is leaf-spot. This disease causes irregular spots on the leaves and, in serious cases, the crop is greatly reduced. The plants should be sprayed with Bordeaux mixture before or just after blossoming. In badly infected areas, the plants should be mowed close to the ground and the leaves burned.

Information regarding the insect pests or diseases will be furnished by the California Experiment Station upon request. A description of the trouble and a sample of the affected leaves or branches should be sent for identification.

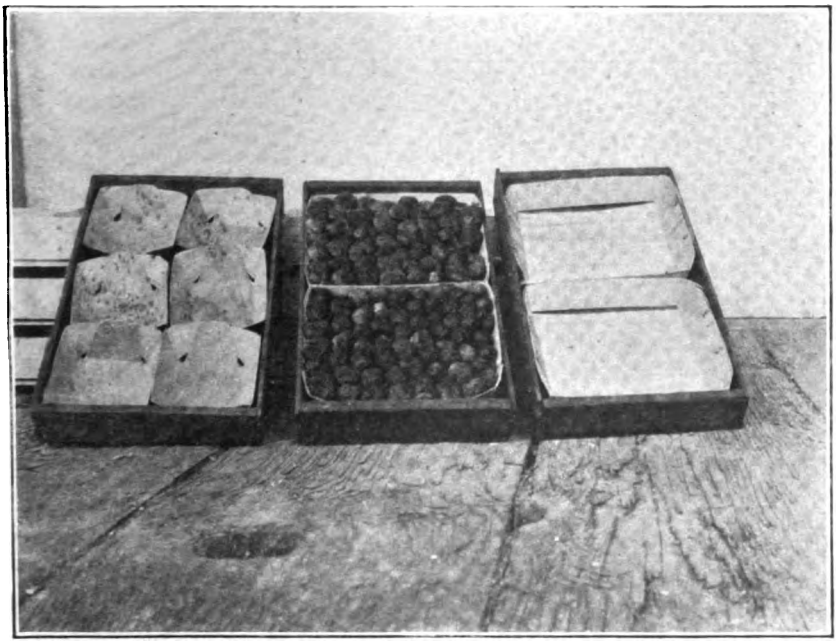

Fig. 12.—Drawers from fruit chest showing the two sizes of cups generally used. (Photograph by permission U. S. D. A.)

HARVESTING

Berries are the most perishable fruits that are now being grown on a commercial scale, and cannot be handled in the same way as even the tender kinds of tree fruits. The length of time between reaching a stage of maturity when they are of highest quality for table use and when they begin to deteriorate is very short. The perishable nature of this class of fruit necessitates extremely careful handling, prompt shipping, and immediate consumption. No class of fruit has better flavor or quality when at the proper stage of ripeness, or decays more quickly when not properly handled.

Brambles.—The brambles should be picked often during the height of the season. During the early part of the picking season, the patch should be picked

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every three or four days, but when the berries begin to ripen faster, the entire patch should be picked each day. Berries should be picked directly into the box or cup in which they are sold, and should not be handled by regrading or sorting. The marketable grades should be picked directly into the market packages, and the soft fruit either picked into a separate receptacle or dropped on the ground. Berries crushed in picking should not be mixed with the sound fruit. The berries should not be left standing in the sun, but should be placed in the shade, under a tree, or in the packing house. No berries should be picked when wet from rain or fog. All fruit should be taken to market or shipping station as soon after packing as possible. The use to which the berries are to be put determines the

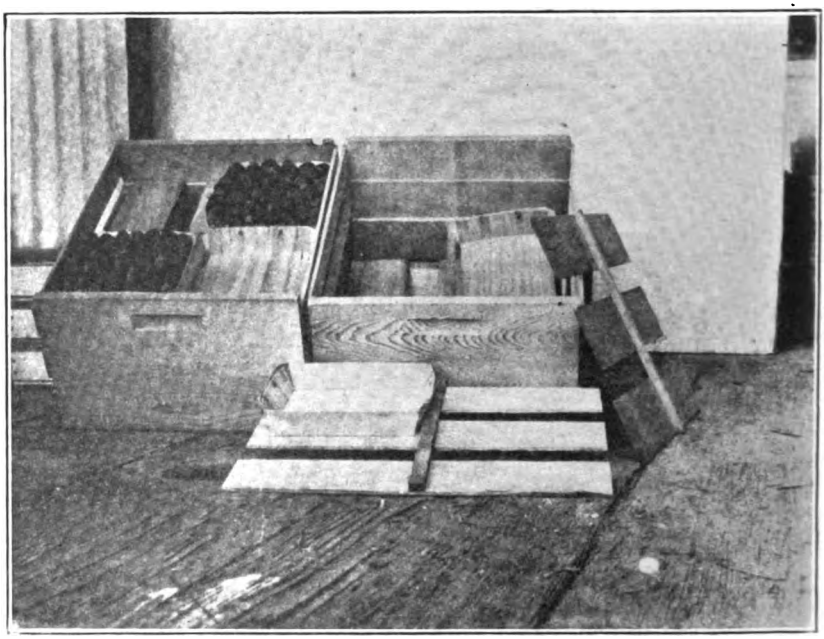

Fig. 13.—Type of crate used for shipping berries. (Photograph by permission U. S. D. A.)

exact stage of ripeness at which they should be picked. Generally speaking, raspberries may be used for local or near-by markets when they separate from the "core" without crumpling or falling apart. For long-distance shipments only the firmer berries should be used, while the softer grades are utilized for canning. Blackberries, loganberries and other brambles in which the berry does not separate from the core or receptacle, for long-distance shipments must be picked when hard and firm, though well colored. Fruit which is somewhat softer, although not mushy, may be used for local markets. The common package for marketing this class of fruits locally is the twenty-drawer chest (fig. 11), each drawer of which holds two large or six small cups (fig. 12). Crates holding twenty-four one-quart boxes (fig. 13) are universally used for long-distance shipments and also, to a limited extent, in shipping to local markets.

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Currants and Gooseberries.—Currants are usually harvested in two pickings. There is no danger of the fruit becoming soft under ordinary conditions, but during a period of hot weather injury from scalding often results. The danger of loss from this cause is reduced by making two pickings. The fruit is in right condition for picking when all the berries on the cluster are red. The cluster should be picked whole, and the berries not separated from the stem, as when the berries are picked from the cluster, the entire package is moistened with the juice which escapes and decay quickly follows. Gooseberries are sometimes picked by holding a portion of the bush in a gloved hand and picking with the bare hand. On a large scale they are picked by stripping the leaves and fruit into a shallow box and then removing the leaves by running the entire picking through a fanning mill which blows out the leaves and pieces of branches. As the fruit is picked while still hard and green, no injury results from this method of handling.

Strawberries.—Strawberries are picked every day or two throughout the season. For long-distance shipment the berries are picked showing considerable green or white color, and while still very hard in texture. For near-by markets, the fruit must be well-colored but still firm and not mushy. Berries must be picked with the calyx attached and preferably a short portion of the stem. Strawberries may be "faced" or turned with the stem down and the attractive side uppermost, but the quality and size of the fruit must be the same throughout the package. They are marketed in the twenty-drawer chest (fig. 11) or in crates containing twenty-four one-pint boxes.

VARIETIES

The following is a brief description of the principal varieties of the different small fruits grown in California. It is not intended to be a complete reference to all varieties of small fruits, but simply a short discussion of the varieties now being grown or those considered worthy of trial.

Blackberries

Lawton.—Bush sturdy; erect; strong grower; heavy producer. Fruit is large, black, sweet and of excellent quality. Mid-season. The standard blackberry in California.

Kittatinny.—Strong grower; hardy; productive. Fruit is large, glossy black, sweet and of good quality. Mid-season to late. Popular.

Early Harvest.—Strong upright grower; hardy; good producer. Fruit is medium to small, sweet and of good quality. Season is early and fruit ripens over long period. Susceptible to leaf rust.

Crandall.—Vigorous; hardy; productive; ripens fruit over long season. Fruit is large, firm and sweet. Season early. Very popular especially in southern part of state.

Wilson Junior.—Hardy; upright grower and productive. Fruit is large and black. Season early.

Evergreen (Oregon Evergreen).—Bush vigorous; strong growing; drooping; perennial. Fruit is large, firm, sweet and of good quality. Season, late to very late. Worthy of trial.

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Mammoth.—Extremely vigorous; fairly hardy; rapid grower and a heavy producer. Canes are semi-trailing or trailing. Fruit is very large, long in shape, black, sweet, and soft when fully ripe. Very popular in California, ripening early to mid-season, usually between the loganberry and the Lawton.

Hybrids

Loganberry.—Canes are vigorous, hardy and exceptionally productive; trailing in habit, covered with a large number of rather small spines. Fruit is long, large, dark-red in color, sub-acid in flavor and good in quality. Excellent for shipping or canning. Season early. Grown in nearly all berry sections of California.

Phenomenal.—A variety of loganberry very similar to the original variety. Held by some growers to be indistinguishable from the original loganberry. Vines are strong, vigorous and productive. Fruit is large, long, red in color, sub-acid in flavor, larger than loganberry but softer in texture. Generally given same culture as loganberry.

Himalaya.—Bush extremely vigorous; very spiny; trailing or semi-trailing; perennial and reported a heavy producer. Fruit is roundish in form, medium size, and juicy. Season from June to late fall.

Dewberries

Gardena.—Vigorous grower; heavy producer. Fruit is large, glossy black, firm, sweet and delicious. Season early. Popular in southern part of state.

Lucretia.—Hardy and productive; berries are large, sweet, black in color and soft; said to ripen shortly after the Gardena. A general purpose variety.

Red Raspberries

Cuthbert.—Hardy; vigorous grower, with heavy foliage which protects fruit from sunburn. A heavy and regular bearer. Fruit is deep red in color, large, conical, firm, separates readily from core and is a good shipper. One of the most popular mid-season varieties in California.

Hansel.—Vigorous grower. Fruit is medium to large, and bright red. Season early.

Superlative.—New variety. Fruit is medium to large, excellent flavor, and ripens over a long season.

Antwerp.—An old variety, not generally planted in this state. Plants not vigorous except under favorable soil and climatic conditions. Fruit is dark red, firm, of excellent quality and a good shipper.

Black Raspberries

Gregg.—Plants are strong, hardy and productive. Berries are medium in size, firm and sweet. Mid-season. The standard variety of black-caps for home or commercial planting.

Kansas.—Strong; vigorous grower; hardy and productive. Fruit is early in season, medium size, black, firm and of good quality.

Souhegan.—Fruit is large, firm and sweet. Season early.

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Currants

Cherry.—Bush is fairly vigorous, hardy, medium in size and a good bearer. Fruit is large, bright red and borne on rather stout, well-filled bunches. The leading variety in the central part of the state. Somewhat subject to attacks by mildew and cane borers.

Fay.—A new variety, said to bear more abundantly than the cherry. Fruit is said to be less acid than the former.

Perfection.—A new variety, grown very successfully in eastern currant districts. Bush is vigorous, healthy, strong-growing and very productive. Berries are large, bright red, borne on long well-filled bunches, flavor acid. Worthy of trial in this state.

Pomona.—Bush is vigorous, hardy and a good producer. Berries are medium in size, red and hang well after ripening.

White Grape.—One of the white varieties. Manner of growth and bearing same as that of red currants. Does not yield as heavily as red varieties and does not have the brisk acid flavor of the former. Grown principally for home use.

Gooseberries

Downing.—Bushes are vigorous, sturdy and productive. Berries are medium to large, oval in shape, smooth, yellow sprinkled with red dots when ripe. Flavor sweet and pleasant when fully ripe. A good market variety.

Houghton.—One of the oldest varieties. Bushes are strong-growing, long-lived and productive. Berries are small, roundish, dull red when fully ripe, skin smooth and thin. Ripens in advance of the Downing. Chief disadvantage of this variety is the small size of the berry. Resistant to mildew.

Champion.—Bush is a strong grower and a prolific bearer. Berries are medium size, smooth, roundish-oval, sweet when fully mature. Resistant to mildew.

Industry.—One of the English varieties. Bush is vigorous, upright, and a good bearer. Berries large and dark red when ripe. Subject to mildew.

Berkeley.—Bush is fairly vigorous grower and good bearer. Berries are very large and ripen early. An English variety and subject to mildew.

Strawberries

Marshall.—Plant is vigorous, healthy and a good producer of new plants. Flower, perfect. Fruit is medium to large, dark red, flesh somewhat lighter in color, firm, roundish-conic in shape. Grown in Fresno district, upper interior valleys and in Watsonville district. Identical with Banner.

Jessie.—Average in size and vigor; fairly good plant producer; good bearer. Flower, perfect. Fruit is medium to below in size, roundish conic, dark red, flesh, red and firm. Grown in Fresno district and upper interior valleys.

Gold Dollar.—Medium in size and vigor; erect; good plant maker. Flower perfect. Fruit, rather elongated conic, dark red; flesh, somewhat lighter, firm. Grown almost exclusively in the Florin and Newcastle section. Ripens early and produces over a long period.

Malinda.—Plant is inclined to be small; fair plant producer. Flower, perfect. Fruit is small in size, conic in shape; flesh is a dark red, firm and has a firm core. Grown, with others, in Pajaro Valley.

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Oregon.—Plant is medium in size, vigorous, erect, good plant maker and a heavy producer. Flower, perfect. Fruit, medium to large, broad conic, dark red; flesh, medium red and inclined to be soft. Popular in Pajaro and Santa Clara valleys, and in the Sebastopol section.

Klondike.—Vigorous and fairly good plant maker; fair producer. Flower perfect. Fruit is of fair size, roundish, dark red, firm and a good shipper. Largely planted in region around Los Angeles.

Nick Ohmer.—Medium in size and vigor; is a fair producer and plant maker. Flower, perfect. Fruit is medium in size, roundish-conic, medium red and soft. Grown in districts adjacent to San Francisco.

Brandywine.—Medium in size, compact, a fair producer and plant maker. Flower, perfect. Fruit conic in shape, light to medium red and firm and a good shipping variety. Season is medium to late. Largely grown in Los Angeles section.

Excelsior.—Vigorous; a medium producer and a good plant producer. Flower, perfect. Fruit is medium in size, conic, medium red and firm. Grown in Los Angeles section. Sharply acid in flavor but very early.

Arizona.—A good plant maker; fairly vigorous; a fair producer and drouth resistant. Flower, perfect. Fruit is medium in size, conic, compressed, dark red and firm.

Ettersburg Varieties.—Ettersburg nos. 80, 89, and 121, as grown at the University Farm at Davis, have proved themselves to be extremely vigorous, upright or erect, good plant makers. Have not been tried sufficiently for making any recommendations.

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CIRCULAR No. 165
MAY, 1917

FUNDAMENTALS OF SUGAR BEET CULTURE UNDER CALIFORNIA CONDITIONS

BY R. L. ADAMS

The commercial growing of sugar beets necessitates not only conditions of soil, water, and climate satisfactory for the growth of the beet, but transportation facilities to a mill, as sale to a sugar company constitutes the only available market for the crop. Sugar beets are a bulky crop low in value per unit of weight, and beet-growing areas are of necessity confined to localities on some railroad line, usually within 100 or 125 miles of a mill, and to lands situated within easy hauling distance of the railroad or mill.

An idea of the present confines of the beet-growing territory in California may be gained from the location of the fifteen mills now (1917) operating or soon to be ready for operation. These mills are in counties as given below:

County	No. of factories
Alameda	1
Glenn	1
Kings	1
Monterey	1
Orange	5
San Bernardino	1
San Joaquin (now building)	2
Santa Barbara	1
Tulare	1
Ventura	1

Some idea of the rapid development and resultant importance of the beet industry to the state may be gleaned from the fact that in the relatively short period of ten years the acreage has increased from approximately 60,000 acres in 1906 to an estimated acreage of over 144,000 in 1916. By three-year averages the acreage has risen from an average annual acreage for the years 1907–09 of 64,227 acres to

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98,960 acres for 1910–12, and to 118,600 acres for 1913–15. Indications point to an increasingly larger area for the near future.

General Requirements for Sugar-Beet Production.—California is climatically well adapted to the production of sugar beets because absence of rain from May to October permits the beets to mature normally, and to be readily harvested, while the control of soil moisture by irrigation insures ideal conditions.

Sugar beets will yield profitable crops on widely varying soils, ranging from sandy loams to heavy adobes, provided the land is properly handled. Depth is essential for best development and two, three, or more feet of uniform soil free from hardpan or standing water is necessary. The heavier types of soil tend to produce the largest tonnage, but are somewhat more difficult to work.

While beets will tolerate more alkali than most field crops, lands heavily charged with sodium chloride or sodium carbonate will not produce the best crop of beets. Sodium sulphate is less injurious than the other salts.[1]

Ideal land for beet culture should be level and should consist of soil of friable clay loam nature four or more feet deep. The subsoil should be free from hardpan or preponderating amounts of gravel. Organic matter and plant food must be abundant and alkali must not be present in any but very small quantities. Soils of such nature now producing good yields of barley, potatoes, beans, alfalfa, corn, or any other ordinary field crop, will prove to be good beet soils.

The beet can use generous amounts of water to advantage, and in fact ample moisture is essential for the production of heavy tonnage. Different soils require different amounts of water, but as nearly as a general rule can be given, from eighteen to thirty acre-inches of water, properly distributed or available throughout the growing season (as explained under irrigation) will be required to mature the crop.

To make its best growth the beet requires a long growing season. Once it is established, it is not especially sensitive to either light frosts or hot weather. Sections having a growing period of from 150 to 200 days, when temperatures do not drop below 20° F. or rise much above 100° F., with ample sunshine to promote sugar formation, and not subject to too severe drying winds, are suited for sugar-beet production.

Beets Are Grown under Contract.—In arranging for the growing of beets, the usual practice is for the interested grower and the mill

[1] For discussion of tolerance of beets to alkali, see Bulletin No. 169, Cal. Agr. Exp. Station.

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to sign a contract, the terms of which govern the growing and sale of the crop. This contract is signed early in the season, even before the seed is planted, and stipulates the conditions under which beets must be raised if they are to be acceptable to the sugar company. Usually the contract indicates the acreage to be sown, binds the company to advance and supply the seed at a given price, limits the grower to the use of this seed only, regulates the time of harvesting and delivery, defines the limiting size and sugar content of an accept-

Fig. 1.—Sugar beets nearing maturity.

able crop, points out the place of delivery, sets the rate of payment, and allows deductions for improperly topped or dirty beets.

Two Kinds of Contracts.—In general, two kinds of contracts are offered to growers; one providing for the purchase of the crop upon a flat tonnage basis; the other upon a sliding scale of payment, depending upon the sugar content of the beet. All contracts define a limiting point below which the quality of the beet may not fall, and a limit which the weight may not exceed. As a rule, 11 or 12 per cent sugar, with individual beet weights not to exceed four pounds, are the desiderata.

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The flat rate or tonnage method provides for payment to the grower for all beets delivered to the company on the basis of weight alone. The grower is reimbursed to the extent of the actual tonnage delivered at a given rate per ton for all loads, less deduction for dirt, green tops, and trash, provided the beets meet the requirements of minimum sugar content and maximum weight. Under this plan beets testing, for example, 14 per cent sugar bring the same returns as beets testing 20 per cent.

In the sugar-content contract, payment is made on the basis of quality by providing a flat rate for all beets of a minimum sugar content, with provision for an increasing rate of payment based upon each additional percent, or fraction thereof, of sugar present in the beet. An example of a sliding-scale rate of payment is a contract calling for so much per ton (for example $4) for all beets of acceptable weight having not less than the low limit in sugar content (for example 11 per cent), with provision for the payment of so many cents (for example 25c) for each additional per cent increase in sugar content or fraction thereof above the required amount.

Some companies offer a choice of contracts based upon either method of payment.

Study the Contract.—To fully understand his responsibilities in connection with the financing and growing of a crop, every signer should fully acquaint himself with the provisions of his contract. This simple course will later avoid confusion and possible unnecessary misunderstanding.

In making out a contract, the factors to be considered by both grower and mill are:

1. Selection and amount of acreage to be planted, with special reference to its fitness for sugar beet production and the capacity of the farmer to grow the beets.
2. Source and kind of seed, with reference to price and germinating qualities.
3. Conditions governing the growth of the crop, especially as to time of thinning, irrigating, and time of harvest.
4. Conditions governing the harvest of the crop, such as time of delivery, and terms of acceptance, as point of topping, deductions for green tops and dirt, and restrictions concerning individual weight of beets or their sugar content.
5. Rate and time of payment, including any bonuses.
6. Payment of freight and demurrage charges.
7. Financial advances to growers and the manner of protecting the mill.
8. Assignment of contract.

Kind of Contract Determines the Beet to Grow.—When a choice of methods of payment is offered, the grower will be helped to a decision as to which to select by a study of the land to be planted to beets. In sugar-beet growing the crop will run, as a rule, either to heavy tonnage of beets fair to good in sugar or to light tonnage of beets rich in sugar. Apparently tonnage and sugar content are

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more or less opposed characteristics of healthy beets, and while the two merge on common ground of medium weight and medium richness, the extremes of heavy weight and excessive sugar, or light weight and low sugar are rarely found together. Beets to be grown under conditions of deep, rich, friable soils, supplied with ample moisture, properly planted and cared for, with a long season of cool weather conditions in which to make their growth, will tend toward heavy tonnage and moderate to good sugar. Beets grown on the light, sandy, warm soils, under climatic conditions tending to be hot and dry during the growing season, will tend to be light in weight and rich in sugar.

The first contract a grower makes must of necessity be based upon the judgment of others as to what his land will do. After the first season any grower should be in a position to decide intelligently for himself which kind of contract best meets his interests. An illustration may make this point clearer.

A certain grower has a piece of land capable of producing fifteen tons of 16 per cent beets. We will assume that factory contracts are optional under which payment will be made at: (A) $5.50 per ton f.o.b. cars, for all beets containing not less than 12 per cent sugar, or (B) $5 per ton f.o.b. cars for 12 per cent beets and 25c for each additional percentage of sugar. Under these contracts this grower will secure $5.50 per ton under schedule A and $6 under schedule B. It is obvious which schedule he should secure to obtain the greatest returns.

A second grower has two types of land and desires the greatest returns. The first type will produce fifteen tons of 16 per cent beets, the second type but nine tons of 20 per cent beets. Given his choice of contracts as outlined in the preceding paragraph, he finds that payment will be $5.50 per ton for the product of either field on the flat rate basis, $6 per ton for the 16 per cent beets, and $7 per ton for the 20 per cent beets, on the sliding-scale rate. For either field the sugar content contract is preferable. To determine his final selection of land, however, he must compare his *per acreage* returns, and he then finds that the land producing fifteen tons of beets at $6 will return $90 per acre, while nine tons of beets, even at the high price of $7 per ton, will only return $63 per acre.

In general, the grower's contract based on purchase of beets by the sugar content is the more profitable (and more fair), and the land capable of producing the heaviest tonnage will give the greatest acreage returns. But whether tonnage or sugar content is desired, the aim should always be to produce a well-filled root, symmetrical in outline, possessing a single tapering tap root free from sideroots, and carrying a single, compact, well-formed top.

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CULTURAL METHODS

Preparing the Seedbed.—A good seedbed is the first essential in the production of sugar beets. If maximum crops are to be secured, the land must be placed in a fine state of cultivation to as great a depth as possible. This means the subjection of raw land, the eradication of the residue of former crops, such as alfalfa roots or corn stubble, the breaking up of plow soles, and the destruction of all weed growth. Usually a plowing is given two months or more in advance of seeding and the soil worked down to a fine seedbed. Since the beet is a deep-rooting crop, it is essential to plow as deeply as is consistent with the past handling of the land, regulating the depth of plowing to prevent the bringing up of more than an inch or two of soil heretofore unplowed. When deep plowing is not possible or when a hard layer or plow pan exists beneath the depth reached by the plow, it is well to follow the plowing with a land cultivation to an additional depth of four to six inches. This tends to break up any plow pan which may exist and provides a still deeper seedbed. The objects of thorough preparation are:

(1) To furnish a medium in which the beet can freely develop, permitting the root to penetrate the subsoil, and preventing growth above ground; (2) to provide a deep feeding area; (3) to increase the water-holding capacity of the soil, and (4) to destroy such insect and fungus troubles as are susceptible to at least partial control by this means.

Following the plowing, subsequent working consists in the frequent use of the land cultivator, ringroller, plank drag, harrow, and possibly a replowing to conserve moisture, destroy weeds, and prepare and preserve a seedbed until the planting season opens. Thorough cultivation of this sort results in a seedbed capable of germinating a high percentage of seed and in conditions favorable to the growth of the young seedling from the very beginning.

In plowing land left rough from harvesting the previous crops or from a previous plowing, it is very advisable to roll or disk the field in advance of the plowing with a view to breaking up the clods, which if turned under would prevent the production of a good seedbed. The degree of packing which must be practiced depends on the season, being less when future rainfall is expected and more when the rainy season is about over and drying conditions prevail. The aim is to secure in the final result a firmed cultivated area well united with the undisturbed subsoil beneath. When much manure, weeds, or similar material has been turned under, special care is needed to

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insure a proper contact. If the amount of green stuff is excessive, it is sometimes necessary to reirrigate and rework the land before a satisfactory seedbed is secured.

In general, the fall and early winter preparation is the more important. In the spring, plowing is usually not required, unless weed growth or packing is excessive. In fact, in handling all types of heavy soil the less they are opened up in the spring the better, as the limits of their being either too wet or too dry are very close. Fall plowing a little on the dry side, immediate harrowing, frequent use of the weed cutter during the winter, followed in the spring by a shallow cultivation, ringrolling, dragging, and harrowing to settle the seedbed will prove the best policy to follow.

Since irrigation is generally practiced in sugar-beet production, the necessary ditching, levelling, checking and preparation of the field for the handling of the water precedes the preparation of the seedbed. For lands to be irrigated by the furrow system the plow furrows should run with the slope of the land to permit thorough saturation of the land when the water is turned on the field.

Time of Planting.—The commercial time of planting in California covers a period from October 1 until June 1, local conditions largely influencing the time when the seed is sown. In general, as near as a rule can be given, fall planting—October, November, and December—is more common in the southern portion of the state; early spring planting—last of January and February—in the Sacramento and San Joaquin valleys; and later spring planting in the coast sections, such as Monterey and Santa Barbara counties. Local conditions will determine the best time to sow, but as a general recommendation, as early planting as is possible to be strongly recommended. Although early planting carries with it attendant difficulties of soil preparation, weed destruction, thinning and hoeing, danger of root rot and crusting, the increased tonnage of beets obtained fully warrants early planting, even though it becomes necessary to replant occasionally. In the interior valleys where warm weather begins at an early date, early planting is absolutely essential to insure well-established growth before the heat and dryness of late spring and summer descend upon the fields. The danger of Curly Top—described under beet troubles—further justifies the general recommendation that early planting should be the rule.

In certain sections, especially in the Sacramento Valley and some of the central coast sections, it is possible to plant beets so early that a considerable percentage will throw up seed-stalks. If this seed formation progresses too far, the sugar content of the crop is reduced

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and the beets become too woody for profitable working. "Early planting," therefore, must be construed as meaning the planting of the seed as early as possible, while guarding against planting so early that seed production replaces satisfactory maturing. The concensus of opinion is that the preferable time of planting for various sections is:

Sacramento and San Joaquin valleys, January 15 to March 15.
Southern California, October 1 to April 1.
Central Coast counties, February 1 to June 1.

Late planted beets sometimes look greener and have larger and more luxuriant tops than early planted beets, but the actual tonnage of roots secured is greater in the early plantings. The cooler weather which exists when early planted seedlings are coming up causes them to develop a small, compact top, but the greater supply of moisture available for their use and the longer growing season result in a larger average root.

When planting in advance of copious spring rains, followed as they usually are by heavy winds, which combine to crust the soil, planting should be made early enough to give the seedlings time enough to form several true leaves in advance of the storms, or else seeding should be delayed until after these storms are past.

If seeding is done in late spring when sufficient moisture is not available to germinate the seed, an irrigation should be given before seeding. Success does not usually attend any effort to irrigate seed with a view to inducing germination, as crusts form to a detrimental extent.

If crusts are formed by irrigation or rainfall before the seed germinates, care to break this crust is essential before the young germinating plantlets turn yellow (noted by turning over the crust and inspecting the germinating seed). This can be overcome on most soils by a light harrowing across the rows with the spike-tooth harrow, inclining the teeth to the rear or setting them back to the point where they merely penetrate the crust, or by a rolling, or by the use of "spiders" on the cultivator, utilizing two "spiders" for each row and running on the outer edges of the row. Usually, however, under such conditions replanting is advisable and, in fact, is necessary if the seedlings are yellowed or the final stand is irregular.

In some sections, especially if the land is charged with alkali, early planting is practiced, even though the land is dry, the seed being placed very close to the surface and the winter rains being counted upon to firm the seedbed, germinate the seed, and keep the plants growing.

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Methods of Planting.—The mill usually furnishes the necessary seed to the farmer at a price as close to cost as possible (in late years occasionally even below cost). Several advantages accrue to the farmer from such an arrangement. He secures seed on credit and at low cost. The seed selected is the best foreign or domestic available, of strains tested out to prove their worth in the community, and each lot as received, is usually tested for germination and purity.

In planting, the seed is sowed by drills capable of planting four or eight rows at once, spaced to distances ranging from sixteen inches to twenty-four inches between rows, with eighteen or twenty inches the more common spacing. The drills place any desired amount of seed at depths ranging from one-half inch to three inches or more, cover the seed, and if desired, compress the soil above them. The width of row depends on the beet desired and the growing conditions. Profitable close spacing is possible only on fertile lands with proper conditions of water and climate, and careful attention to the care of the growing crops. On less fertile lands, or where water is insufficient, greater spacing is desirable. A seedbed properly prepared for the reception of the seed will permit a one-inch or shallow planting and insure a stand. If deeper planting is necessary, greater attention to the preparation of future seedbeds will be in order.

The depth of planting should be carefully determined. The rut in which the seed is dropped being comparatively narrow, large seed balls will not reach the bottom and care should be exercised when using a supply having a majority of large seed balls, to run the seeder deep enough so that the seed will be placed at the desired depth.

Early in the season, when the subsoil is inclined to be cold and future rains are expected, quick germination is desired, and shallow planting to secure surface warmth should be the rule. Under these conditions, the minimum amount of seed is used, with little or no pressure being applied to the press wheels of the machine. Later in the season, when the moisture is receding or evaporating rapidly, more seed is provided and placed deeper in the soil. In instances where the moisture is three inches or more from the surface, it is desirable to clamp "clod pushers" upon the runner brace, just in advance of the runner and at an elevation of about one and one-half inches in a parallel line above the bottom of the runner. This reduces the amount of soil through which the young sprouts must penetrate to reach the surface. To conserve the moisture and to hasten germination, some pressure is applied to the press wheels which pack the soil directly over the seed.

From twelve to twenty pounds of seed are required per acre, with

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fifteen pounds or more as the general rule. When a large acreage, 100 acres or more, is to be seeded, the work should be so planned that a delay in seeding occurs sufficiently often to prevent too great a rush of work at thinning time and to lengthen the ripening season. A four-row drill will seed about ten acres a day and thinners can handle about one-fourth to one-half acre per man daily, thus indicating something of the limits of time in which the work should be completed.

Cultivation.—Some growers roll their fields with a smooth roller as soon as the crop is well up, in advance of any cultivation. The rolling disturbs any crust which may occur, packs the land, insures a more even distribution of moisture, facilitates the use of the cultivator, and materially lessens the labor of thinning. Cultivation is started as soon as the rows are well defined and is designed to provide the three-fold object of weed destruction, aeration, and maintenance of a loose earth mulch for retention of water. The first cultivation precedes the thinning, using cultivators equipped with weed knives to remove all weeds between the rows, and should cut as close to the beets as possible.

Subsequent cultivations are given at intervals of ten days to two weeks and continued until the size of the plants prohibits stock and implements from passing down the rows. The narrow chisels (1¼-inch to 1½-inch) and the duck-foot cultivator teeth with weed-cutter attachment are generally used, being attached to special two-horse adjustable cultivator frames capable of cultivating four rows at a time. The wheels are built to castor and are controlled by a foot pedal enabling the operator to shift the direction in following the rows. Deep cultivation should be the rule as the season progresses, to permit even expansion of the growing beets, and easier plowing-out at harvest time. The total number of cultivations given the crop vary in different sections, but more rather than less than the usual practice should be the rule.

Destruction of all weeds is important. Morning glory or Johnson grass must not occupy the land given over to beets, and to a lesser degree the same statement applies to bur clover, pigweed, mustard, dock and other common weeds.

Thinning.—Since each seed-ball contains several beet seeds, more plants will be produced than are needed, and when the young beets have four true leaves well developed, they must be thinned to provide sufficient area for unobstructed development of the selected plants. Hand labor using short-handled beet hoes is the only practical method of doing this work as no machine for the purpose has thus far been perfected. Sufficient labor should be available to complete the thin-

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ning before the third pair of leaves is fully grown. Blocking ahead of thinning, where it can be done, is advisable. Blocking consists in first hoeing out the spaces to be left, leaving the remaining beets in small bunches from which the beet selected to remain will be chosen in the final thinning.

The spacing varies from eight to eighteen inches, the same qualifications holding in determining the distance as pointed out above with reference to the distance between rows. Spacing from eight to ten inches is perhaps the more general practice. In thinning, care should be observed to space accurately, to reserve the sturdiest beets, to pull by hand the beets close to the one which is to be left, to hoe off the remaining surplus deep enough to prevent resprouting, and to avoid unnecessary digging around the plant to be left.

The thinning should be regulated so as to result in the selection of the strongest beets, their even distribution throughout the row, and the destruction of all weeds in the row or immediately around the beets.

Irrigation.—As sugar beets draw quite heavily upon the moisture supply in the soil, irrigation is necessary except under unusually favorable natural conditions. Different soils require various treatment with regard to irrigation, and no definite rule can be given which is applicable to all conditions. A proper regulation of soil moisture means, enough available to germinate the seed and bring it well through the thinning period, a maximum quantity of moisture from the eight or ten-leaf stage until six or eight weeks before harvest, and a gradually diminishing supply to permit proper ripening with its attendant increase in sugar content. The need of moisture may be determined by examination of the soil itself to the depth to which the root system is developing, by a darkening to a purplish or bluish green of the light green color of normal beets, by increasing flabbiness of root or leaf stem, and lack of thrift, or by a wilting not caused by excessive sunshine or heat of the day. On large tracts it is better to start irrigating too early rather than too late, as best results will not follow when beets are permitted to reach the stage of actually suffering for want of water.

The flooding system of irrigating has been the prevailing custom in this state, but present tendencies are in the direction of more furrow irrigation and less flooding. This is apparently a wise change in methods. Whatever the system used, care must be exercised to provide ample moisture without over-irrigation throughout the soil area occupied by the root system. An insufficient amount will reduce tonnage, while an oversupply is not only not economical, but tends to

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remove available plant foods by carrying them off through drainage. The rule in irrigating should be to study the movement of the water in the soil by means of a probe, soil augur, or shovel, and aim to provide only the optimum amount of water.

The quick going-back of beets once they show the need of water emphasizes the necessity of applying water to promote a steady, uniform growth when the first signs of distress appear. Only a few days of insufficient moisture are enough to check growth seriously, the length of time depending on the climatic conditions which in turn regulate the movement of the moisture. In hot, dry, windy weather a "going back" will be much more rapid than during cool, foggy spells. Growing beets which become very yellow for lack of water are beyond the stage when they can give the largest returns from irrigation, but even then an application will often pay.

Water applied to mature beets during hot summer weather tends to preserve the beets. It also assists by loosening the ground so that plowing-out is easier. Applied at this time, however, water will not increase tonnage to any appreciable extent. During cool weather, or at a time of year favorable to beet growth, water may prove detrimental, by causing renewed growth, especially if this growth results in the formation of seed stalks, as these are usually produced at the expense of the sugar content. The beets may weigh a trifle more because of the water taken up, but the actual solid content is not improved.

Every irrigation should be followed by a cultivation as soon as the land is dry enough to sustain stock. The cultivation will prevent baking, crusting, and cracking, with resultant loss of moisture and pinching of the beets.

Fertilizers.—Commercial fertilizers have never come into general use in growing sugar beets in this state. Trials with different fertilizing ingredients have been run by various mills, but the results have not been sufficiently uniform to warrant extensive applications of mineral fertilizers. Doubtless as time goes on more attention will be given to fertilizers, especially on the lighter, or the longer farmed, or on peaty types of soil.

Fall application of stable manures to beet lands is a common practice in southern California, and is gradually receiving more attention in all parts of the state. Stable manures are a valuable asset in continuous beet production and deserve extensive use, especially on the lighter soil types.

Green manuring, consisting in the growing and plowing-under of green crops of such plants as rye, vetch, bitter clover, bur clover

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and field peas, is a practice worthy of greater extension where the supply of organic matter is in need of replenishment or if stable manure is not to be had. When irrigation is available, green-manure crops can sometimes be grown in the interval between regular farm crops.

On land utilized for more or less continuous beet growing, plowing under the beet tops, rather than feeding them to stock, is meeting with increasing favor.

Maturity and Harvesting.—The time of harvest is usually designated by the mill contracting for the beets. This varies somewhat

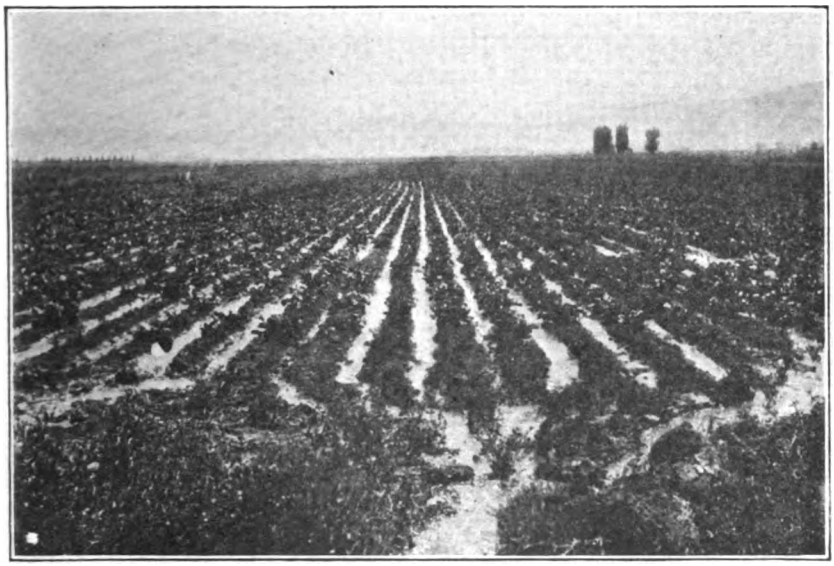

Fig. 2.—Furrow irrigation of sugar beets.

from season to season, as the starting of the mill campaign is postponed until there is reasonable assurance of an ample and steady supply of satisfactory beets. So far as the beets themselves are concerned, harvest may go forward any time after maturity. Maturity is indicated by a circle of dead outer leaves on the individual plant, and a general yellowing appearance of the entire field, while mill laboratory tests for sugar of typical field samples provide an additional and very satisfactory check.

The time required to reach maturity varies with the time of planting. Fall-sown beets require seven to eight months, early spring-sown beets six to seven months, while late spring-sown beets in favorable localities will mature in four to five months. The quickest maturation

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takes place in spring plantings in localities of hot summer weather, and on light soils; the opposite is true in cooler sections, on the heavier types of soil, or in fall plantings.

Harvesting is accomplished by "plowing out" the beets. Specially constructed implements are run down the rows and loosen the plants in place. The beets are then removed by hand, several rows thrown together in one long windrow or in piles and the tops cut off by hand labor using heavy butcher knives. A very satisfactory method is to throw the beets from nine rows together side by side in one long row, tops all pointing one way, and to follow down the row in topping, standing each beet on its cut surface. A space of nine rows allows sufficient room for the wagons to pass through and places the beets in a position for quick loading. In different sections, however, the prevailing custom must be followed to a large extent, since the type of labor doing the hand work has its own way and is not easily changed.

All beets to be correctly topped must have the leaves and all green portions of the crown removed. This means topping at the ground-line. The men who do the topping must be closely watched in this regard and proper topping insisted upon. The green crowns contain salts which interfere with sugar extraction in the mill and deduction for such beets is always made on delivery. In addition to paying for the transportation and handling of a portion of the crop for which he receives no returns, the grower who ships green tops is taking from his land the very plant food elements most valuable to him. Analyses indicate that of all plant foods removed by a beet crop in making its growth, approximately 75 per cent of the total is contained in the leaves and crowns, with but 25 per cent in the roots. The importance of proper topping cannot be too strongly emphasized.

After being topped, the beets are loaded on wagons for delivery to the freight cars or to the mill. Where special unloading platforms or dumps are not available, rope nets are required to facilitate the removal of the load. The extensive construction of unloading dumps is, however, largely doing away with the net method.

Yields.—Yields of beets vary within wide limits, from fields which produce barely enough to pay operating expenses to exceptional commercial yields of thirty tons or more. In general, ten tons represents about an average yield in this state, while fifteen tons is considered a good yield. Some experienced growers, who operate under favorable conditions, obtain an average of twenty and even of twenty-five tons from fields containing extensive acreages. Since, in general,

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eight tons of roots are required to pay the cost of production, every effort should be made to increase tonnage wherever not more than ten or eleven tons represents the usual crop.

The Sugar Beet in Crop Rotation.—On land annually receiving the beneficial effects of the mill waste water, it is safe to say crops of sugar beets can succeed one another for an indefinite length of time without exhausting the soil's fertility. The amounts of plant food and lime deposited in the waste water are usually more than enough to replace that removed by the beet crop. Only with increases in weeds or other influences detrimental to beet production, will the undesirability of continued beet culture develop.

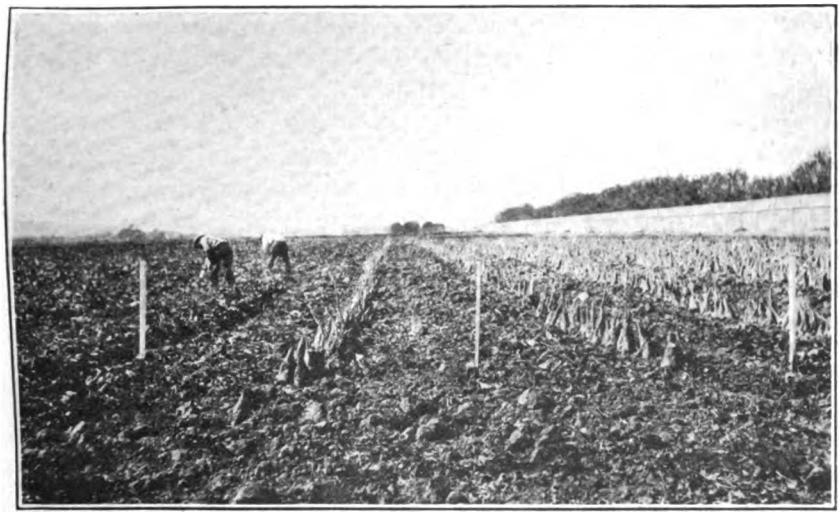

Fig. 3.—Practical Method of Handling Sugar Beets at Harvest Time.

On land not receiving the waste water the number of crops which can be grown consecutively cannot be specifically stated. New land will produce crops for many years, and the gradual increase in productivity is a matter of common knowledge. Lands receiving intelligent handling, especially with reference to manuring, will produce beets for many years.

Two reasons for rotation may be advanced, the time when the rotation will start being necessarily an individual matter. The first reason is based on gradually decreasing yields of beets through diminishing fertility or increase in beet troubles. Rotation then follows as a natural means of building up the land again. The second reason for rotation is the desirability of securing the beneficial effects

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of the sugar-beet crop upon succeeding crops. Large increases in yields of cereals, potatoes, beans, and other field crops follow sugar beet culture. The deep preparation of the soil necessary to provide a seedbed for beets, the careful cultivation and deep working of the land in removing the crop, the available plant foods freed in the decaying beet tops and roots provide an environment capable of producing heavy yields of any of the field crops adapted to the local conditions.

In planning the sequence of crops to be grown it is advisable not to precede beets with any crops which will render the growing of beets difficult, such as the presence of undecayed corn or sorghum stubble or half-killed alfalfa stands, and to guard against the growing of potatoes or beets immediately following one another.

The sugar beet lends itself especially well as a rotation crop in connection with alfalfa, and should prove a desirable change for lands devoted primarily to dairying. As an intercrop in young orchards, where sufficient moisture and fertility is available for both trees and beets, the sugar beet furnishes a satisfactory means of providing an income while insuring thorough and proper working of the soil.

By-Products.—Two by-products of sugar-beet culture are of interest to the California farmer. The first is the mill waste water, mentioned elsewhere, of value to all farmers whose lands are so situated that they can irrigate with this water, which, heavily charged with lime and other elements favorable to plant growth, is of marked beneficial effect.

The beet tops are a valuable stock feed and offer a substantial additional income whenever stock is available for feeding, if their use as green-manure crop can be dispensed with. Care must be taken to avoid feeding of decayed or moldy tops and to watch cattle for choking if they are unused to this kind of feed. Some dry roughage should be fed with the tops to avoid scouring. If these precautions are taken the tops, green or dry, form a valuable addition to the feed supply. Tops are salable whenever stock is available, at from 50 cents to $4 per acre, several localities basing their charges for the tops upon the net tonnage of beets sold to the mill.

In disposing of tops the grower should either have them fed on the land, or return the equivalent in manure, and provide for the removal of all stock whenever the land is wet enough to be in danger of suffering from the tramping of the stock.

Contract Labor.—As beet production requires considerable hand work, especially in thinning, hoeing, irrigating, pulling, topping, and loading, a class of labor able and willing to do this kind of work

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must be available. The usual California farmer will not or can not do this work, even if raising but a few acres. Greatest reliance is placed upon Japanese, Hindu, and Mexican labor. Some Porto Rican, Italian, Greek, and a very little Chinese help is occasionally used.

The common method is for the farmer to contract with some labor "boss," the terms of agreement being drawn up in writing, under which all stipulations as to rate of payment, housing facilities, feeding arrangements, and methods of handling the crop are specified. The contractor agrees to furnish sufficient men to properly care for the crop.

Rates of payment for this work vary in different sections.

Some contracts provide for payment of thinning on a flat acreage basis, as for example $7.50, divided into $5 for thinning, $1.50 for first hoeing, and $1 for second hoeing, with payment for harvest on a tonnage basis, and for other work, such as irrigating, on a daily basis. Other contracts provide for a sliding scale of payment for all work from thinning on through harvest. Here again rates vary, depending on the weediness of the ground, the size of the job, the character of the soil, and the ability and reputation of the farmer as a beet grower. For example, one system of payment for all work done on a tonnage basis is $15 per acre for six to twelve-ton yields. Another schedule provides for payment at the rate of $12 per acre for land producing but six tons, $12.60 per acre for seven-ton yields, and on up by a graduated scale calling for an additional 60 cents per acre for each ton increase in yield.

In summing up the labor situation in beet growing it is well to point out the necessity of ample assurance of labor when needed, as the various kinds of work required must be done on time, and to open negotiations only with reliable contractors. Provisions for field supervision of this labor, and penalties for non-fulfillment of the contract, if such can be included, are extremely desirable.

Beet Troubles.—The limiting factor of sugar-beet production in California today, so far as beet troubles are concerned, is the danger of Curly Top, a disease resulting from the attacks of a small native insect (*Eutettix tenella*), a whitish leaf-hopper one-eighth of an inch long. This insect, feeding upon the plant, infects it in such a way that all leaves subsequently produced come forth curled, yellowish, stunted, and distorted, while masses of fine, hairy rootlets and blackened rings develop upon and within the beet root—the typical Curly Leaf condition known to most experienced growers. The disease is produced by the feeding of even a single insect for as short a time as five minutes. Without going deeply into the reasons, it is well to point out several pertinent factors. *Early* beets grown in cool weather are much freer from Curly Top than those making their early growth during hot weather. Supply of proper conditions for vigorous growth

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reduces the damage. Beets infected after they have ten or twelve leaves will still make a marketable beet in spite of the infection. Proper irrigation will reduce damage, as will cool weather conditions, indicating the desirability, and in some of the warmer sections, the absolute necessity of early planting. In the San Joaquin and Sacramento valleys experience fully indicates the desirability of getting

Fig. 4.—Typical specimen of a sugar beet affected with Curly Top. Note the prominent veining, distorted leaves, and abnormal growth of fine roots.

the seed into the ground not later than March 1 and as much earlier as possible up to the first of January. Even in the cool coast sections early planting is advisable to insure a well developed beet before a serious increase of insects occurs. The insects reach the fields from two sources, those wintering over in the immediate vicinity and those migrating from neighboring ranges of Atriplex, Russian thistle, sage and other plants on which the insects are native, often flying from

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their native habitat to the beet fields. Control, as at present worked out, means planting as early as possible to insure a large beet at the time of exposure, and proper attention to thinning, cultivation and irrigation.

Other troubles occurring occasionally or in certain localities which may require some attention from time to time on the part of growers, but need little more than passing notice here, are the woolly aphis, which forms woolly-like masses in the beet roots; nematodes, or eel-worms, which cause knotty excrescences on the fine roots; small black beetles (*Blapstinis* sp.), one-fourth inch long, which destroy the tiny seedlings as they are coming up; red spider, a green beetle with twelve spots (twelve-spotted *Diabrotica*), a leaf-feeding army worm, wireworms, plant lice, and cutworms, which feed upon the growing beet and are generally easily recognized by every farmer. Compound tops due to excessive growth, woody beets—the result of seed production, two fungus leaf spots (*Cercospora beticola* and *Phoma betae*), a seedling root rot (*Rhizoctonia*), rust, ground squirrels, gophers, and moles, are also worthy of mention in a consideration of beet pests.

Equipment Needs and Costs.—While some special equipment is needed in sugar-beet farming other than that required for general farming, the additional investment is not especially great. For the purpose of taking care of all the work connected with forty acres of sugar beets, the operator will require:

Four to eight 1200 to 1500-pound work stock (depending on type of soil, length of haul, and possibilities of hiring).
Harness.
One fourteen-inch plow.
One spike-tooth harrow.
One plank-drag (preferably equipped with spike harrow teeth).
One land cultivator.
One combined clod crusher and land roller.
One beet seeder (unless rented by mill to grower).
One running gear, four to five-inch tires, rated as two and one-half tons or larger.
One four-row crop cultivator, with assortment of cultivating and irrigating attachments.
One beet plow.
Usual assortment of beet hoes, ordinary hoes and shovels.

On most farms, where general farming is the practice, much of the equipment given here is already available. When the total equipment is to be purchased, the cost will range from $1300 to $3000, depending on whether new or second-hand, and the grade of stock

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and implements sought. In general, however, sugar beet work requires good work stock and well-constructed tools, strong enough to stand a great amount of wear and tear.

For small acreages planted to sugar beets, say considerably less than forty acres, it is usually necessary for two growers to combine their resources and use certain of the equipment in partnership, hire some of the heavy plowing and hauling off done by tractor owners or farmers growing other crops who have stock and implements available at the time of the rush of beet work.

Economics of Sugar-Beet Production.—The cost of producing sugar beets varies within rather wide extremes, depending on what factors are included in determining the costs. If interest, depreciation, and management are taken into account, the cost will reach a figure considerably higher than if only the cost of labor—horse and man—material, and taxes are included. The capacity of the man, kind of land, distance of haul, size of acreage, available labor supply, presence of weeds, costs of water, are factors which vary greatly with different growers and in different communities.

To show the approximate cost of producing the crop, taking only operating expenses into account, the following table is given:

PER ACRE OPERATING COST OF PRODUCING SUGAR BEETS

Market value of Land	*Range*	
High	$400 to $600	per acre
Low	85 to 100	
Usual	150 to 250	
Cost of the Crop		
Preparing land and planting	*Average figures*	
Preparing seedbed ($4 to $12)	$7.00	per acre
Seed	2.25	
Seeding	.50	
Growing the crop		
Irrigating—labor ($1 to $4)	3.00	
Irrigating—water ($2 to $6)	4.00	
Thinning and hoeing ($4.50 to $8)	7.00	
Cultivating ($1 to $3)	2.00	
Harvesting		
Plowing out ($2.50 to $5)	3.00	
Pulling, topping and loading		
Under ten tons (75c to $1)	.90	per ton
Ten tons and over (50c to 75c)	.60	
Hauling (two miles)	.65	
Taxes and insurance		
Average land	3.00	per acre
Good land	5.00	

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Market Value of Yield, f.o.b. cars or factory

High	7.50 per ton
Low	4.50
Average	5.50

By-Products

Tops (50c to $4)	2.00 per acre

Using average figures as given, the cost, value, and profit per acre for ten, fifteen and twenty-ton crops are:

Yield	Cost (Operating Costs) Per acre	Per ton	Values per Acre (Average Price) Per ton	Per acre	Profits Per acre	Per ton
Ten tons	$37.25	$3.73	$5.50	$55.00	$17.75	$1.77
Fifteen tons	37.75	2.52	5.50	82.50	44.75	2.98
Twenty tons	42.75	2.14	5.50	110.00	67.25	3.36

These calculations illustrate the desirability of good yields. Although the increase tonnage raises the cost per acre somewhat, the cost per ton is markedly less as the yield increases. The profits per acre increase with the larger yield in greater proportion than the increase in yield itself amounts to, for while the fifteen-ton yield is but 50 per cent more than the ten-ton yield in weight of crop, the profits are 250 per cent more. In the same way a 100 per cent increase in yield over the ten-ton crop increases the profits over 375 per cent.

SUMMARY

Proper conditions of soil, water, climate, and transportation are essential to sugar beet production, commercial areas being confined to sections where sugar companies are operating as sale to a mill constitutes the only available market.

California offers sections well adapted to the production of the crop, as demonstrated to some extent by an increase of acreage from sixty thousand acres in 1906 to over one hundred and forty-four thousand in 1916.

Sugar beets are commercially grown only under contract made between the grower and a sugar mill. Contracts are of two general classes, based on either tonnage or sugar content. The grower should acquaint himself with the terms of his contract both for his own protection and to guide in determining the kind of beets to raise.

The observance of deep soil preparation, formation of a good seedbed, early planting, frequent cultivation, proper thinning, optimum moisture supply, and maintenance of soil fertility are necessary in obtaining the best yields.

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Preferable times of planting are:

Sacramento and San Joaquin valleys, January 15 to March 15.
Southern California, October 1 to April 1.
Central coast counties, February 1 to June 1.

In harvesting, the beets should be topped at the groundline to insure minimum removal of plant foods.

As approximately eight tons of roots are needed to pay the cost of production, and ten tons is about an average yield, an increased yield for the state at large is worth striving for.

Beets are placed in rotation when yields begin to decrease or to secure the beneficial effects of their culture on subsequent crops.

Sugar beet by-products of interest to the California farmer are the mill waste water and the tops. Both are of interest in maintaining fertility, while the tops are of additional value for stock feed.

Much hard work is necessary in producing a crop and labor able to do the manual work must be assured.

Given good soil and good soil management, Curly Top is the limiting factor in sugar-beet production. Its control may be materially aided by early planting and attention to supplying proper growing conditions. Other troubles occurring from time to time, or in certain localities are of lesser importance.

Some special equipment is needed in sugar beet farming, but the investment is not unduly great. From $1300 to $3000 will furnish equipment sufficient for forty acres.

The cost of growing sugar beets varies greatly with conditions and the tonnage obtained. Large tonnage increases profits by decreasing operating costs per ton, the profits increasing in much greater proportion than the size of the yields.

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CANNING FRUIT IN GLASS JARS OR WAX TOP CANS

BY FREDERIC T. BIOLETTI AND WILLIAM V. CRUESS

1. Make a false bottom to fit inside an ordinary stove wash-boiler. This bottom may be a piece of heavy wire screen or a wooden grating.

2. Prepare the fruit by peeling, coring, and pitting as needed.

COLD-PACK METHOD

3. Pack the fruit as prepared directly into the jars or cans.

4. Complete the filling of the cans with hot water, sugar syrup, or grape syrup. Jars should be warmed first to avoid cracking.

The fruit will keep equally well whichever liquid is used. The addition or the amount of sugar is a matter of taste. It can be added later when the fruit is used. The usual sugar syrup for apricots, peaches, plums and berries is made by dissolving 3½ lbs. of sugar in a gallon of water. For apples, pears, quinces, prunes, and cherries 2¼ lbs. of sugar to the gallon is sufficient. If neutral 65° grape syrup is used, from 5½ to 3½ lbs. should be used per gallon of water.

5. Place the full cans or jars with loose covers on the false bottom in the wash boiler, adding water to about two-thirds their height. With cans boiling water is best; with jars it should be simply warm. A second tier may be placed on a wooden rack resting on top of the first tier.

6. Place the cover on the boiler and heat to boiling. The boiling should continue for twenty minutes for apricots, free-stone peaches, plums, berries, apples and cherries. For pears, cling-stone peaches, and unripe fruits, thirty minutes are necessary to cook the fruit.

7. The tops of the jars should be screwed down tight while still boiling hot and placed upside down or lying down on a table to cool. Wax-top cans should be removed quickly and sealed while still boiling hot.

HOT-PACK METHOD

By this method, the fruit after preparation is cooked in an open pot with the water or syrup. When cooked sufficiently it is simply ladled while still boiling hot, into the cans or jars, which are then sealed immediately. Jars must be heated by placing in boiling water before being filled.

In this way a larger quantity of solid fruit can be packed into a jar or can. The liquid remaining in the cooking pot may be used to cook a second lot of fruit.

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CANNING FRUITS WITHOUT SUGAR

BY DIVISION OF VITICULTURE

The sugar used in canning or bottling fruit is for the purpose of improving the flavor and is not necessary for preservation.

Fruit of any kind suitable for canning may be preserved without any sugar. When the fruit is consumed, the sugar can be added exactly as is done with fresh fruit. If the fruit when canned is thoroughly ripe it may be consumed without this addition of sugar and is sweet enough for many tastes.

The ordinary methods of home canning are used. These are the "cold pack" and "hot pack" methods.

For the former the fruit is washed, peeled, pitted or cored as needed and packed tight in clean, scalded cans or jars. Water is then added, boiling in the case of cans, and as hot as possible without cracking the glass in the case of jars. Scalded caps or covers and rubbers are then put in place loosely and the filled cans heated in a vessel of boiling water for twenty to forty minutes. An ordinary wash boiler furnished with a wire screen or a wooden grating on which to place the jars is suitable for this purpose. The boiler should contain enough water to rise about half-way up the sides of the jars.

While still at the boiling temperature the jars or cans are removed, sealed and placed to cool, lying horizontally or upside down.

For the "hot pack" method the prepared fruit is placed in a large pot on the stove with a little water to prevent burning. After heating to the boiling point and cooking until the fruit is tender and some of the juice has exuded, it is poured into the cans or heated jars by means of a perforated or wire ladle and a wide funnel. Sufficient juice from the pot is then added just to cover the fruit and the cans or jars sealed. These are then heated in the boiler for about twenty minutes. For a second batch of the same fruit the juice remaining in the pot should be used instead of water for the preliminary cooking.

With some fruits there will be an excess of juice. This can be used in the canning of other kinds of fruit or for making blended jams, marmalades or jellies. In cases where there is not sufficient juice to cover the fruit when placed in the jars sufficient hot water may be added for this purpose.

The riper the fruit, providing it is sound, the more sugar, flavor, and nutriment it contains.

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CANNING OF FRUIT AND VEGETABLES

BY FREDERIC T. BIOLETTI AND WILLIAM V. CRUESS

All kinds of fruit and vegetables can be preserved in cans or glass jars by methods easily applied in the home.

Preparation.—The material is cleaned, peeled, pitted, and sliced as desired. This has nothing to do with preservation, but is simply to make the food more attractive and to avoid preserving useless material.

Blanching.—Some vegetables are improved by dipping for a few minutes into boiling water before canning.

Exhaustion.—As little air as possible should be left in the jars or cans. This is accomplished by heating the filled cans nearly to boiling before sealing. The heat expels the air and sealing hot prevents its entrance during or after cooling.

Cold Pack.—The prepared fruit or vegetables are packed into the cans and then as much water, syrup, or brine added as the can will hold. The filled cans are heated to nearly the boiling point, then sealed and heated to boiling after sealing.

Hot Pack.—The prepared material is first cooked with the necessary water, syrup or brine in an open kettle and when hot placed in the cans and sealed immediately. In most cases this is sufficient for preservation, but an additional heating after sealing is often necessary.

With the cold-pack method the canned material retains its form better, but more liquid is needed. The hot-pack method is more economical of heat and more solid material can be packed in the can.

Sterilization.—In order that any food shall keep in a can or jar it must be heated sufficiently *after sealing* to kill all germs which cause spoiling. This is called "processing" by canners.

The necessary time and temperature of heating vary with the nature of the food. Acid materials, such as tomatoes and most fruits, are easily sterilized by heating nearly to the boiling point for twenty or thirty minutes. Neutral materials such as most vegetables cannot be safely sterilized in this way. They can be sterilized, however, by one of the following methods:

Repeated Heatings.—Vegetables heated after sealing are allowed to cool and are reheated the next day. A third heating a day later is sometimes necessary.

Higher Temperatures.—Sterilization may be insured by heating to several degrees above the boiling point of water. This can be done in special pressure cookers designed for this purpose.

Acidification.—After the addition of a little wholesome acid, such as vinegar or lemon juice, to vegetables, they can be sterilized in the same way and as easily as fruit.

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CANNING VEGETABLES IN JARS AND WAX TOP CANS

BY FREDERIC T. BIOLETTI AND WILLIAM V. CRUESS

1. Make a false bottom to fit inside an ordinary stove wash-boiler. This bottom may be a piece of heavy wire netting or a wooden grating.

2. Prepare the vegetables as for cooking and in convenient form for placing in the cans. Root vegetables should be brushed clean, peeled and cut into convenient slices or pieces. Green beans should have their strings removed and then be cut into short lengths. Peas should be shelled. Corn should be cut off the cob. Peppers should be scalded and the skin removed. Squash should be peeled, the seeds removed, and the flesh cut up into small pieces. Asparagus should be blanched or parboiled by dipping into boiling water for about three minutes immediately before canning. Artichokes should have some of the outside bracts removed and the hard tip cut off with a sharp knife.

3. The prepared vegetables are packed tight into the jars or cans which are then completely filled with brine containing three ounces of salt to a gallon of water. Before using, this brine should be acidified with lemon juice or vinegar. For corn ten fluid ounces (about one and one-half teacups) of lemon juice should be used to a gallon of brine, for beans and peas seven fluid ounces (about one teacup), and for other vegetables five fluid ounces (about threefourths of a teacup). If ordinary vinegar is used about twice these quantities are necessary. The acidified brine should be poured hot on to the vegetables.

4. The filled cans and jars are then placed, with their covers in place but loose, on the false bottom of the boiler. Hot water is then poured into the boiler until it reaches to about three-fourths of the height of the jars. A second tier may be placed on a rack resting on the first tier.

5. The boiler is then covered and heated to boiling, for one hour for most vegetables. Pumpkins, beans and corn require two hours.

6. After this heating remove and seal quickly, while still boiling hot, by screwing down the tops of the jars or applying the wax to the cans.

This is a thoroughly safe and satisfactory way of preserving vegetables. With some vegetables the acid may be omitted, but in this case two or three repeated heatings are necessary and this lowers the quality of the food to some extent. Reheating is not practicable with wax-top cans.

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DRYING WINTER VEGETABLES

BY DIVISION OF VITICULTURE

Many kinds of vegetables can be dried and thus made available for use throughout the year. The methods are simple and similar to those used with fruits, and can be applied anywhere in California.

The method described here is suitable for turnips, carrots, beets, potatoes and other similar root vegetables.

1. Peel or scrape the roots and cut into slices ¼ to ⅜ of an inch thick.

2. Spread in a single layer on wooden trays. Those used for fruit or raisin drying are good. Suitable light trays can be made from pine shakes or even from old boxes. They should be about 2 ft. × 3 ft. with a 2-in. cleat on each end and a ½-in. strip on each side.

3. Expose the sliced vegetables on the trays to the fumes of burning sulfur. An ordinary "sulfur box" used in drying fruits can be used.

A simple sulfur box can be made of a large dry goods box or of a wooden frame covered with ordinary tar paper to make it fairly air-tight. It should be large enough to hold six to twelve stacked trays. It should be open at the bottom and if large have a door at one side for the insertion of the trays. If small it may be simply put over the stack of trays. It is placed on the ground with the open side down over a hole at one end in which the sulfur is burned. It should be long enough so that the trays do not come over the sulfur hole at the end.

As soon as the box is filled with trays of the sliced vegetables, the sulfur, in a shallow iron or earthenware pan, is placed in the hole and ignited. The door of the box is then closed. In from ten to twenty minutes the sulfuring is complete. A handful of sulfur is sufficient for a large box.

Vegetables can be dried without sulfuring, but the color, flavor and keeping qualities are less perfect and the drying slower. Potatoes are particularly improved by sulfuring.

4. Place the trays in the sun until the vegetables are dry. This will require two to five days in good weather.

5. The dried vegetables may be kept in stone-ware jars, closed bins or heavy sacks. They should be protected from moths, weevils and other insects. If they become infested, the insects may be killed by heating the dry vegetables in an oven for about five minutes, or by placing them in a tight covered box and allowing a little bi-sulfid of carbon to evaporate from a saucer placed on top just below the box cover. Half a cupful is enough for a box 2 ft × 4 ft. × 3 ft.

6. Dried vegetables must be soaked in cold water for 24 hours before being cooked. A pinch of carbonate of soda added to the water makes them more tender. They can be used for nearly all the purposes of fresh vegetables, but are particularly suitable for soups and stews.

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FRUIT JUICES

BY FREDERIC T. BIOLETTI AND WILLIAM V. CRUESS

Refreshing beverages can be made from most juicy acid fruits by the following simple method:

1. Crush the fruit into an enameled or aluminum pot.

2. Heat on the stove slowly with frequent stirring until the fruit is thoroughly softened, which will be when it reaches a temperature of 130° to 140° F. Use a thermometer and do not exceed a temperature of 140° F.

3. Remove from the fire and let it stand from eight to twelve hours. Then press out the juice and strain, through a cloth bag, several times, to remove the pulp.

4. Scald bottles and fill with the strained juice to within one and a half inches of the mouth. Close with corks which have been boiled in water for ten minutes and tie down the corks with string.

5. Lay the bottles on their sides in a pot or boiler of water. Heat to 180° F. and keep at this temperature for fifteen minutes. A screen or rack at the bottom will prevent breaking.

6. Remove the bottles, dry the corks with a towel, and when nearly cold dip the ends of the necks into melted paraffin.

Heating to over 180° F. or for too long a time injures the flavor.

Highly flavored grapes are the best for juice. Muscat is improved by the addition of equal quantities of Zinfandel or other acid variety.

The juice of loganberries and blackberries is improved by sugar which may be added when the juice is used.

With citrus fruits, it is best to press out the juice before heating and to avoid the oil from the skin. Pomelo (grape fruit) and lemon juices are good, but orange juice soon loses its flavor.

Pomegranates are excellent for this purpose.

Dilution with sweetened or carbonated water when using improves some juices.

The juice may also be poured hot (180° F.) into cans or jars and sealed immediately. These are then stood upside down until they cool.

Bottles of fruit juices should be kept in a cool place. If kept lying on their sides, they are less likely to become mouldy near the corks. Before using bottles should be stood upright for a few days to allow any sediment to settle.

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JELLY STOCKS

BY FREDERIC T. BIOLETTI AND WILLIAM V. CRUESS

A jelly stock is simply the juice of boiled fruits containing the necessary pectin and acid. It differs from jelly in that it contains no added sugar and remains liquid. It can be kept for years and made into jelly at any time simply by boiling with sugar. It is prepared as follows:

1. Crush or slice the fruit into a pot and, except for very juicy fruits, add a small amount of water.
2. Boil until tender, usually from five to thirty minutes.
3. Press while hot in a cloth and strain through a jelly bag. Red currants, loganberries, and crab apples contain an excess of pectin and the pulp left in the bag may be reboiled for ten minutes with water of about half the volume of the juice. The reboiled pulp is pressed, strained, and both lots of juice mixed. The first juice contains most of the flavor and acid.
4. Test the jelling quality by boiling a small cup of the juice with an equal quantity of sugar. If it fails to jelly, boil it down more in a wide shallow pot.
5. Heat to 130° F. and place in clean scalded bottles, filling to within 1½ inches of the mouth, and close with corks of good quality. The corks should be boiled or steamed for half an hour before using and should be tied down. The juice may also be poured hot (175° F.) into cans or heated jars which are closed immediately.
6. The bottles are then laid on their sides in a pot or boiler of hot water (180° F.) which is kept at this temperature for fifteen minutes. The cans and jars are stood upright in the boiler. A wire screen or wooden grating at the bottom is necessary to prevent breaking. After heating, the bottles or jars are removed and laid on their sides to cool.

Loganberries, apples, currants, cranberries, guavas, lemons and pomelos (grape fruit) give good results. Combinations of loganberries and strawberries, apples and apricots, etc., may be used, one fruit supplying the pectin, the other the flavor. The two juices may be blended immediately or kept separate until they are made into jelly.

To make jelly, the stock is well shaken and poured into a pot with an equal measure of sugar. The mixture is then boiled and poured into jelly glasses. This method defers the purchase of the sugar until the jelly is needed for consumption.

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LIVING EXPENSES

BY M. E. JAFFA

An employer of labor asked the University of California Agricultural Experiment Station for a statement concerning the increased cost of living as a basis for adjustment of wages with its employees. These estimates are here published with the belief that they may be of value to others similarly situated.

It is impossible to estimate the expenses of any family without knowing all the conditions, but there are certain fixed items of expense, and the percentage of increase in cost is known for others. These form a good basis for calculation in regard to the effect of high prices on the mode of living of a family of small income and will be discussed in turn. The accompanying table shows how the varying prices of foodstuffs affect the total food cost.

TABLE SHOWING INCREASE IN COST OF FOOD FROM MAY, 1916, TO MAY, 1917

MINIMUM DIET ON WHICH HEALTH CAN BE MAINTAINED FOR WORKING MAN, HIS WIFE AND THREE CHILDREN BETWEEN FOUR AND FOURTEEN YEARS OF AGE

	Food and cost for 1 month			Market price per lb.	
	Cost				
	Pounds	1916	1917	May 1916	May 1917
Meat and Fish	50	$8.00	$10.00	$0.16	$0.20
Milk	120	4.80	6.00	.04	.05
Eggs	6	1.08	1.56	.18	.26
Beans	8	.40	1.60	.05	.20
Flour	60	1.92	4.80	.032	.08
Cereals	17	1.02	1.36	.06	.08
Macaroni	4	.32	.50	.08	.125
Rice	10	.60	.83	.06	.083
Potatoes	35	1.05	2.17	.03	.062
Vegetables	55	1.65	1.65	.03	.03
Fruits	50	2.50	2.50	.05	.05
Butter	8	2.40	3.60	.30	.45
Oil and Fats	10	2.00	2.50	.20	.25
Sugar	25	1.75	2.25	.07	.09
Coffee and Tea	....	1.00	1.00	.30	.30
Sundries	....	2.50	3.00	....	....
First total		$32.99	$45.32	per month	
Extra for man		2.55	3.25		
Second total		$35.54	$48.57	per month	
Per person per day		.237	.324		

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NOTE 1.—The first total is adequate if the man of the family is engaged in ordinary labor. The second total allows for 1000 calories extra food for heavy work. If the labor performed is that of a lumberman or harvest hand, a further increase of three and a quarter dollars is necessary.

NOTE 2.—Additional children will add the following amounts to the food budget:

Between 3 and 6 years, $5.70 per month.
Between 6 and 9 years, $6.75 per month.
Between 9 and 13 years, $7.90 per month.
A girl over 13 years, $9.00 per month.
A boy over 13 years, $10.50 to $11.00 per month.

NOTE 3.—The item of "Sundries" includes such articles as corn starch, syrup, cheese, salt, pepper, mustard, yeast, etc.

The diet here presented expresses the minimum on which health and efficiency can be maintained. It admits of many rearrangements between the staples of the same class, according to the preferences of people of different nationalities: more macaroni, less rice; more vegetables, less fruit; more meat and less milk; but no appreciable variations could be made in the cost without a corresponding decrease in the nourishment. In view of this fact the increase in cost of 33⅓ per cent is serious.

It is unnecessary to say that many families live on much less than the diet given, which may account for a large proportion of stunted children, many diseases, early death or inefficiency.

Clothing.—This item of expense varies greatly according to the ages of the children and the ability of the family to live up to any kind of a standard. But the increase averages 33⅓ per cent. The most important item under this heading is shoes, the price of which has increased in greater proportion than that of other articles of clothing. It is impossible to reduce the cost of shoes, as can be done with other kinds of wearing apparel by making up cheap material at home.

Shoes show an increase in price of 50 per cent at present, but this will undoubtedly be changed to 100 per cent in the near future when the retailers are obliged to replace their stock at the ruling wholesale prices.

An investigation has shown that not only are shoes higher, but the cost of repairs is greater now than formerly, both on account of deterioration in the quality of the shoes and an increased cost of repair materials. The following estimate of the shoe cost for the family considered is conservative and shows an increase of 50 per cent for the past year.

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COST OF SHOES PER MONTH FOR FAMILY OF FIVE

	1916	1917
Shoes	$3.25	$5.00
Repairs	2.00	3.00
	$5.25	$8.00

Rent.—The prices paid for rent in cities by families of small income range from $12 to $17, so that $15 seems a fair average for the budget of the family.

Since the food cost is often 40 or 50 per cent, and rent 20 per cent of small incomes, and since clothing which often takes the lion's share of the balance has increased 33⅓ per cent, it would seem that enough data are at hand to warrant a preliminary budgetting for a family with an assumed income of $75 a month.

	1916	1917
Rent	$15.00	$15.00
Light	1.50	1.50
Fuel	3.00	3.00
Food	33.00	45.00
Shoes	5.25	8.00
	$57.75	$72.50
Balance	17.25	2.50
Income	$75.00	$75.00

In 1916, there was a balance of $17.25 a month to cover such other expenses as

Insurance	Clothing (except shoes)	Vacation
Organization dues	School incidentals	Recreation
Drugs	Household upkeep	Amusements
Doctor bills	Church support	Incidentals
Dentist bills	Carfares	Emergencies

In 1917 there is $2.50 a month left to cover this long list of items, many of which are unavoidable, others urgent, and few of which can be omitted.

The higher prices have in all probability been met by a reduction in the food supply of the family. Rent *must* be paid, shoes and some little clothing *must* be bought, other incidentals must be met, but food, which is the largest item of expense and is susceptible of manipulation, can generally be reduced. This should *not* be done at the expense of the growth and development of the children and the efficiency and endurance of the adults.

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PRESERVATION OF FRESH EGGS

BY DIVISION OF VITICULTURE

Eggs may be spoiled by the growth of bacteria within the shell or by drying up on account of evaporation through the shell. Both of these causes of spoiling may be prevented by covering the shells with a substance that will prevent the entrance of bacteria and the evaporation of water.

The most convenient substance for this purpose is *sodium silicate,* which can be obtained from most drug stores in the form of a thick syrup for 75 cents per gallon. There are two ways of using it.

One is to make a solution containing one part (by volume) of the silicate syrup and nine parts of pure boiled water. The eggs are placed in a crock, can, bucket, or small keg, and covered with the solution.

The other is to make a stronger solution containing one part of the silicate syrup and three parts of water. The eggs are dipped into this solution by means of a wire basket or collander and then placed on a board or table to dry. Care must be taken that the eggs do not stick together or to the table. A good method is to cover the table with a piece of clean wrapping paper which is then dusted with flour, starch, chalk or other powder. This keeps the eggs from adhering to the table. It is safest, if the eggs are to be kept a long time, to dip them again as soon as they are dry. When the silicate on the eggs is dry, they are packed in boxes of bran or sawdust to prevent evaporation.

The eggs to be preserved should be fresh, clean and preferably infertile. After treatment they should be stored in a *cool room* or *cellar.* Eggs preserved by the dry method are best used within six months.

One gallon of sodium silicate is sufficient to preserve sixty dozen eggs by the wet method; a cost for material of 1¼ cents per dozen.

One gallon of the silicate is sufficient to treat about 200 dozen by the dipping method, or three-eighths of a cent per dozen, to which must be added the cost of bran or sawdust, of which is required about one-half pound per dozen eggs.

Many other methods have been used for preserving eggs. Some of these methods are unreliable, some injure the flavor of the eggs, and none appears to be equal to the methods with sodium silicate.

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PRESERVATION OF VEGETABLES BY SALT AND FERMENTATION

BY DIVISION OF VITICULTURE

Vegetables can be preserved more cheaply than in cans or jars and more simply, for household use, than by drying. The methods make use of the preservative qualities of salt and of lactic acid.

1. *Preservation in Brine.*—The vegetables are first washed, and sliced. They are then placed in a crock or barrel or other wooden vessel containing a strong brine. Metal vessels cannot be used. The brine is made by mixing 2½ to 3 pounds of salt to each gallon of water. The vegetables must be kept submerged by means of a well-fitting wooden cover weighted with a stone or similar object that will not be acted on by the brine.

2. *Preservation in Salt.*—Prepare the vegetables as above. Weigh them and take one pound of salt for each two pounds of prepared vegetables. A layer of salt is first placed on the bottom of a crock or barrel and then a layer of vegetables. Similar layers are alternated until the vessel is full, finishing with a good layer of salt. A wooden cover is then applied and weighted as in the first method. After a few days there will be a considerable shrinkage in volume and the vessel can then be filled with more layers and weighted as before.

These methods are suitable for most root vegetables, string beans, cabbage and cucumbers.

3. *Preservation by Fermentation.*—Cabbage, string beans, beets, and cucumbers can be preserved by covering them with a weak brine and allowing them to undergo spontaneous fermentation out of contact with the air.

The vegetables, prepared as under (1), are mixed with salt at the rate of one-quarter to one-half of a pound of salt to ten pounds of vegetables and tightly packed in a deep crock or barrel. They are then weighted down with a tightly-fitting wooden cover and a heavy stone. The salt and pressure force out the juice of the vegetables and they decrease in volume one-third to one-half. After a day or two more vegetables and salt may be added and the weight replaced.

If kept in a warm room (65 to 70 degrees F.) a gaseous fermentation commences and continues for several weeks. This fermentation produces lactic acid, which preserves the vegetables. When the fermentation is over and the vegetables taste a little sour the liquid is drawn off and replaced with a brine containing one-half of a pound of salt to one gallon of water. In this they will keep in good condition for a long time if well protected from the air.

The large quantities of salt used in these methods must be removed by soaking before the vegetables are eaten.

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POULTRY AS A MEANS OF CONSERVING THE FOOD SUPPLY

By J. E. DOUGHERTY

Among suggested ways for husbanding the food supply recommended by the Committee on Resources and Food Supply of the California State Council of Defense is the saving of kitchen waste on the part of families living in towns and suburban districts by keeping six to twelve hens to feed such materials and make an otherwise wasted by-product of the kitchen into fresh eggs and table poultry. Poultry products are going to be very high in price as long as stock feeds remain at the exceptionally high prices for which they are now selling.

Eggs have been going into cold storage this spring at from 24 to 35 cents per dozen for extras as against 18 to 22 cents per dozen a year ago. The same is practically true with poultry. This will affect the prices of poultry and eggs next winter. It behooves every consumer of poultry and eggs, and that means every one in the nation, to consider seriously all feasible ways and means for lessening the cost of poultry products this winter. One practical way is to turn kitchen waste into eggs by feeding it to a small pen of fowls in the back yard.

There is no other kind of live stock, with the possible exception of rabbits, that is adapted to so wide a variety of conditions as poultry. They have their place as an adjunct to general farming, they form a splendid combination with orcharding, go well with a dairy in utilizing the skim milk to advantage, and when kept in small flocks by the town and suburban dweller, they represent a most important means of reducing the increasing cost of living. Six to a dozen Plymouth Rocks, or Rhode Island Reds, or any other of the popular breeds, in a neat house with a small yard located at the rear of one's lot are not only an attractive addition to the premises, but also furnish a very profitable means of disposing of table scraps and good kitchen refuse that would otherwise find its way to the garbage can and from there to the city incinerator or dump—a total waste. Such table scraps and

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kitchen waste will supply a goodly part of the necessary feed for a half dozen or so hens so that only a small amount of other feed need be purchased. Then, too, such scraps furnish the fowls a great variety of materials which they relish and which aids wonderfully in stimulating egg production. The writer is convinced, after making most careful observations. that the good (and sometimes remarkable) success secured by poultry raisers with small backyard flocks is due to the choice variety of appetizing materials the fowls get in the form of table scraps and the great amount of attention and care given them by all members of the family. All animals thrive under good treatment and well repay their owners for good care given them. A comparison of the results secured with large and small flocks would indicate that these results are in proportion to the amount of care given to each individual hen to a large degree. This is one explanation of the excellent results so often obtained by enthusiastic painstaking suburban dwellers.

It is not necessary to furnish one's small flock of fowls, where a good supply and variety of kitchen scraps are available, with anything but a small amount each morning of some good grain mixture in addition to grit, oyster shell and a little charcoal which may be kept constantly before the birds in self-feeding wooden hoppers. These hoppers can be made at home of wood with very little trouble and at practically no cost at all if lumber from packing boxes is available.[1] Any of the ready mixed scratch grain mixtures are good if one does not care to make one's own. These grains should be scattered in a straw or shavings litter in the scratching pen so that the fowls get plenty of exercise and do not become lazy and too fat to produce well. There is a tendency for the dual purpose breeds, when confined in small yards and fed abundantly, to lay on too much fat, especially as they get older. This will have to be guarded against, by not feeding too freely and making them exercise hard in the litter.

In using up the kitchen scraps to best advantage it is often desirable to run such things as meat trimmings, etc., through an ordinary kitchen meat grinder and mix these with stale bread or biscuits soaked in sour milk or water and squeezed dry to form a crumbly, moist mash which should be fed at the night feed one hour before sundown, giving the fowls only what they will clean up in one-half hour. A little ground oats, corn meal, bran, middlings, ready mixed dry mash, etc., may be added occasionally to such mashes if the supply of table scraps runs short.

[1] California Station Circular 142, free on request, shows detailed plans for construction of wooden hoppers and labor-saving poultry appliances by anyone handy with tools.

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Six or twelve fowls kept in this way will require a very small outlay for special feeds and will not only supply the family with about all the eggs needed the year round, but will also furnish the principal item of a good many chicken dinners if some of the broody hens are set in the spring and a few clutches of chicks raised.[2]

There is no better experience or training for a growing boy or girl than taking care of a flock of chickens. If the flock is placed on a good business footing and the child taught to keep accurate account of all expenses and income, it not only teaches him to appreciate and understand business methods, but also adds to his happiness and interest and teaches him self-reliance. The writer recalls one instance where the son of the house had a little back yard flock which he owned and cared for most assiduously. He kept a careful book account and his mother bought all of the eggs and chickens he had to sell at the prevailing retail price in the local stores. Chickens, pigeons, garden patches, etc., handled by children in this way under the intelligent and sympathetic guidance of parents are of immense value in training children along business lines as well as in bringing out the very best in their characters. A love and understanding of animals is a broadening influence to any one.

For the man who rents his home, it is easily possible to construct a small shed-roof, open-front hen house with four-foot rear wall and six-foot to seven-foot front wall and built in knock-down construction, so that when moving to a new place, the henhouse can be as easily taken apart and moved as a bed. The sides, floor and roof can be made as separate units which are easily assembled or taken apart. Attached to the house, can be a knock-down wire-covered and wire-sided yard which can also be assembled or taken apart very easily.

The hen house may be five feet by seven feet or six feet by six feet in size to hold eight to ten hens; six feet by eight feet or seven feet by seven feet to hold twelve to fourteen hens; eight feet by eight feet or seven feet by nine feet to hold fifteen to twenty hens. The portable run may be five feet wide, twelve to sixteen feet long and two feet high and covered with a wire mesh panel. Such a small house constructed of one-half inch tongue and groove ceiling of Oregon pine, white cedar or redwood, whichever is cheapest, can be easily moved from one part of the yard to another, so as to keep the fowls on fresh, clean ground, and if neatly built and painted will prove just as attractive as the neatest of garages, and far more sightly than the average woodshed.

[2] The Poultry Division, University Farm, Davis, will furnish free on request detailed instructions for feeding and caring for setting hens and chicks.

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Another important item is the droppings from such a flock, which will greatly increase the production of garden truck and the luxuriant growth of flowers and lawn.

A good laying hen should produce eleven to twelve dozen eggs per year, so that ten hens should lay 1254 to 1368 eggs annually, allowing for a normal 10 per cent mortality, which will give an average of nine and one-half hens for the year. A total of 1254 eggs for the year would give an average daily egg production of 3.4 eggs, or sufficient for the entire egg needs of the average small family.

If such eggs would cost the consumer an average of 3½ cents each if purchased at the grocery store, the annual cost would amount to $43.89, which is the interest on $733 at 6 per cent per annum.

EXPENSE

6 per cent interest on house and run @ $25, cost of materials	$1.50
Interest on ten fowls @ $1.50 each	.90
Loss of one-half hen, allowing 10 per cent mortality per year	.75
Cost of feed at 4 cents per pound, if one-half, or thirty-six pounds per year per hen must be bought	13.68
Cost of 300 pounds straw or shaving litter and nest material @ $5 per ton	.75
Cost of grit, shell and charcoal	.60
Cost of one-half gallon disinfectant	.75
Total expense	$18.93

INCOME

Value of 1254 eggs @ 3½ each	$43.89
Value of 300 pounds manure @ $5 per ton	.75
Total income	$44.64

Labor income or net profit over above equals $44.64—$18.93, or $25.71.

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Growing Vegetables Under Contract

BY STANLEY S. ROGERS

OBTAINING CONTRACT IN ADVANCE OF PLANTING

For the one who wishes to know in advance where his crop is to be sold and what price it will bring, raising vegetables under contract will be found very satisfactory. In order, however, to secure a contract there are a few conditions which the grower must meet, namely:

1. Production should be in quantities large enough to be attractive to the buyer; ordinarily not less than an acre for each vegetable.

2. It is necessary to have favorable soil, moisture, and climatic conditions for growing vegetables of desirable quality.

3. Crops should be mature for shipment at the season they are in demand.

4. A uniform pack must be maintained and the vegetables put up attractively.

5. The contractor must know that vegetables of suitable quality can be produced in the section.

6. The buyer must have confidence in the grower's ability to produce crops of desired quality.

After the grower is confident that he may meet the above requirements the next question which will arise is how to obtain a contract. The largest markets for contracting vegetables in advance are the canneries which are situated in most cities of California and it is a good plan to visit several of those in the immediate vicinity before deciding on the one with which to contract.

Aside from growing for the cannery it is sometimes possible to produce vegetables under contract for the wholesale produce companies. These firms may be found in nearly all the cities in the state and may easily be located by consulting with the stores who are selling vegetables, or with the Chamber of Commerce. For his own satisfaction the grower would do well to visit as many of these firms as possible before contracting.

The contractor furnishes such information as the kinds of vegetables he wishes, the time at which they should be matured, the amount desired and the price which the grower will receive.

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One of the principal advantages of these markets is that the grower may produce larger quantities of certain crops than might be advisable when selling under other conditions. Another feature is that it is sometimes possible to obtain enough money in advance, from the contractor, to pay a part of the costs of production.

CONTRACTING AT TIME OF HARVEST

The conditions enumerated for growing vegetables when contracting in advance of planting are also applicable to this method of marketing.

Vegetables are commonly purchased in this manner by the wholesale produce houses and occasionally by the canneries. The chief advantage to the grower is that he may receive a higher price than when contracting in advance of planting. It also involves more risks than the former, as occasionally the grower will find after the crops have matured that there is no market for them. He will also run the chance of a decline in the price.

After having contracted for the crop another buyer will occasionally offer more than the grower is to receive; under no circumstances should he discontinue his first contract, however, for by so doing he will lose prestige and when the confidence of the buyer is lost it will be very difficult to become established again in the market.

One should only contract with a reliable firm so that he may know he will receive his contract price even if the buyer is losing.

If care is taken in obtaining all available data before the final choice of vegetables is made, and if the grower will give them the proper care, there should be very little difficulty in securing satisfactory returns from growing vegetables under contract.

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The Farm Labor Situation in California

JULY 14, 1917

By R. L. ADAMS
State Farm Labor Agent in California
for
University of California,
State Council of Defense,
U. S. Department of Agriculture

SHORTAGE OF FARM LABOR

Persistent reports and requests for farm help reaching this office indicate a farm labor shortage especially of milkers, teamsters, riders, and others needed for handling and working stock. Irrigators are rather difficult to secure, and the number is limited of laborers for hand work on asparagus, sugar beets, cotton, and similar crops requiring work of a hard, back-breaking kind.

Some of the reasons for this scarcity are that:

First.—Many Austrians, Italians, and Servians, called to the colors, have gone out of the country.

Second.—As a result of troubles between Chinese Tongs, many Chinese are in hiding.

Third.—The formation of Hindu companies for active farming operations for themselves, especially in the rice fields, has reduced the former available supply.

Fourth.—Highway construction has taken men—particularly teamsters—directly away from farm work.

Fifth.—The gradual withdrawal of men formerly fitted for and trained in agricultural vocations into other lines of work, has not been offset by entrance of equal numbers into farm work.

Sixth.—Activity in manufacturing enterprises has drawn upon much of the available labor. Business concerns, realizing that their ultimate success rests on a steady supply of unskilled labor, are consistently outbidding the farmer in wages, housing facilities, working hours and general working conditions. The farmer is thus thrown into competition with all other business requiring unskilled labor such as the lumber companies, iron works, shipyards, quarries, and railroad companies.

That the farm labor need has doubtless been overestimated in making calculations for the season, may be gathered from a post-card survey of all the farmers in seventeen counties, conducted between May 20th and 30th, 1917, by the respective county farm advisers act-

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ing under direction of the State Leader, Professor B. H. Crocheron. In all over 28,000 self-addressed, returnable post-cards such as the following were sent out:

LABOR SURVEY

(Date).....I will need.....men.....women.....children more than I now expect to be able to obtain. They will be needed during a period of.....days, from.....(date) to.....(date) to help in.....work.

Answer Yes or No:

I will provide	I will pay
Room and board	Per box .....
Camping grounds	Per ton .....
House	Per day .....
Water	Per month .....
Sanitary conveniences	

Signature .....

Address .....

The following figures were derived from the returns of this postal-card survey:

SUMMARY OF LABOR SURVEY OF SEVENTEEN COUNTIES OF CALIFORNIA, AS CONDUCTED BY THE COUNTY FARM ADVISERS OF CALIFORNIA

(Results June 28, 1917)

County	Number cards sent	Replies received back	Did not want labor	Wanted labor	Labor wanted			
					Men	Women	Children	Total
Alameda	1900	21	16	5	166	60	....	226
Glenn	1400	138	122	16	95	1	7	103
Humboldt	1985	13	12	1	1	....	....	1
Imperial	3400	225	110	115	1437	229	63	1729
Kern	1965	40	17	23	194	....	....	194
Madera	475	97	50	47	335	31	....	366
Merced	1300	29	15	14	223	2	1	226
Napa	2000	73	51	22	109	3	12	124
Nevada	547	92	88	4	6	3	1	10
Placer	600	12	9	3	4	2	....	6
Riverside	1000	35	25	10	34	10	....	44
Sacramento	500	47	36	11	45	....	....	45
San Diego	2228	32	21	11	57	8	....	65
San Joaquin	4135	58	34	24	115	100	....	215
Solano	1290	86	61	25	119	34	....	153
Stanislaus	2000	557	500	57	252	12	2	266
Yolo	1500	56	39	17	290	71	20	381
	28225	1611	1206	405	3482	566	106	4154

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LABOR SHORTAGE NECESSITATES USE OF EVERY AVAILABLE MAN

To successfully move all crops this year, available sources of help must be sought out and developed. There is available a certain potential supply of a kind of labor in the high school boys, patriotically inclined city dwellers, store clerks, and the output of charitable organizations. Some prison labor is also available.

Out of the vast amount and diversity of work required to carry on California agriculture, this labor cannot do much more than pick up prunes or walnuts, hoe weeds, handle a shovel, pitchfork, or manure fork, or pick berries. Without training or experience this kind of labor is but a "drop in the bucket." Yet to release capable men for other lines of work and to relieve at least partially the present lack in permanent jobs, farmers should make some attempt to utilize as far as practicable this raw labor. To do so to advantage, however, means a degree of patience in showing men how to do the work, a willingness to give new men time to heal blisters and restore lame backs, generosity in the matter of proper living conditions and wages, care to give first tasks commensurate with the beginner's strength, and a desire to foster a liking for and an enjoyment in the work.

To determine the potential supply of high school students available for work, a questionnaire was sent out by a committee, acting under Mr. Will C. Wood, appointed by the State Board of Education to organize a Students' Working Reserve. Replies tabulated from 142 high schools of the state (approximately one-half the total number), and covering about one-third the total high school enrollment, indicated:

	Boys	Girls
Number of returns	13,004	17,086
Number volunteering for some kind of work on farms, in orchards, or in canneries during the summer vacation period	4,194	1,951
Number who expect to be employed on home farm	2,273	1,794
Number who expect to be employed in neighborhood, living at home	3,332	2,408
Number who if properly organized and supervised would accept employment requiring them to live away from home	2,158	541

Two hundred sixty-nine men teachers and 149 women teachers volunteered to assist in supervising groups of students.

An important decision which should result in increasing the possibility of utilizing students is that of the Attorney General of

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California, who has ruled that schools may be officially closed so far as counting attendance is concerned, but that after such official closing teachers may be called upon to continue teaching for the benefit of those who wish to continue under such teaching. Furthermore, under a new law, boards of education have the right to pay salaries of teachers in twelve monthly installments, regardless of the question of whether or not teachers do some teaching in each month of the year.

COUNCILS OF DEFENSE TO ASSIST FARMERS AND FARM HELPERS

The State and County Councils of Defense; the University of California, and the U. S. Department of Agriculture, all recognize the necessity of rendering all possible assistance in bringing together possible labor and farmers who are in need of help. This work is being brought together in the office of the State Farm Labor Agent, 11 Budd Hall, University of California, Berkeley, California.

Since all efforts along the lines of securing labor are for the express purpose of winning the war, the greatest concern will be to help the growers of those things most needed directly or indirectly by the allies, such as wheat, barley, beans, cotton, hay, beef, sheep, pork, cheese, butter, poultry products, corn, sorghum, dried fruits, canned and dried vegetables.

HOW FARMERS SHOULD PROCEED

Farmers who are in need of help should apply to their County Council of Defense who, through its labor representative, will attempt to secure the necessary men locally. If, however, the demand cannot be met in this way the county representative on behalf of the farmer will make application for assistance to the State Farm Labor Agent, 11 Budd Hall, University of California, Berkeley, California.

Each farmer should, however, file his wants with the local County Council of Defense only after exhausting every possible source that he can reach, using every organization equipped with the necessary machinery for bringing farm help and farmers together, such as the regular employment agencies, the Public Employment Bureaus of the State of California operating offices at San Francisco (men), 933 Mission Street; San Francisco (women), Pacific Building; Oakland, 401 Tenth Street; Sacramento (men), 124 K Street; Sacramento (women), Forum Building; Los Angeles (men), 206 Franklin Street; Los Angeles (women), 207 South Broadway; and the United States Employment Service with offices at San Francisco (men), 2 Appraisers Building, Washington and Sansome Street; San Francisco

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Form No. 1

EMPLOYER REQUEST FOR FARM LABOR

Date of Application .....

Name .....

Address .....

Phone .....

Location of Work .....

	Trained	*Untrained*	*Women*	*Children*
Kind of Help	.....	.....	.....	.....
Number Wanted	.....	.....	.....	.....
Age Limit	.....	.....	.....	.....
Nationality Preferred	.....	.....	.....	.....

When Wanted .....

For How Long .....

Wages .....

Housing Accommodations .....

Bedding Accommodations .....

Water .....

Fuel .....

Climate .....

Transportation .....

(How) (Advanced) (Free) (Refunded)

Remarks .....

.....

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Form No. 2

EMPLOYEE APPLICATION FOR FARM WORK

Date.....

Name .....

Address .....

Nationality .....

Sex ..... Age ..... Height ..... Weight .....

Telephone Number .....

(Give in full)

Agricultural Training (School).....

Agricultural Experience (Farm).....

Kind of Work Wanted .....

(*i.e.* haying, fruit picking, berry picking, cotton picking, beet thinning, irrigating, etc.)

Locality Preferred: First choice ..... Second choice .....

How Far from Home will you Pay Fare? .....

Minimum Wage Demand .....

Maximum Hours will Work Daily .....

Have you Camping Equipment? .....

Have you Blankets? .....

When will you be Available? .....

How Long will you be Available? .....

Physical Condition .....

Remarks .....

.....

.....

.....

(Tear off here)

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(women), 108 Customs House, Jackson and Battery Streets; Sacramento, Post Office Building; Fresno, 335 Rowell Building; Los Angeles (U. S. Dept. of Labor, Mr. C. T. Connell, inspector in charge). Other United States employment officers are maintained in the following towns: San Diego, San Luis Obispo, Santa Barbara, Bakersfield, and Calexico.

To insure sufficient data to assist in finding men, when a farmer finds it necessary to approach his local County Council of Defense for assistance, he should accompany his request with the form No. 1 (p. 5) completely filled out.

HOW APPLICANTS SHOULD PROCEED

Those wishing work upon farms should file an application with the local County Farm Labor Agent of the County Council of Defense, who, if he finds himself unable to avail himself of the applicants' services in the immediate vicinity will, in their behalf, report the names of the available men to the State Farm Labor Agent, 11 Budd Hall, University of California, Berkeley, California, for use in other localities.

To insure sufficient data to properly place any applicant, information in full should be given as indicated, in the blank form No. 2 (p. 7).

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COUNTY FARM LABOR AGENTS OF COUNTY COUNCILS OF DEFENSE

Many County Councils of Defense have already appointed a County Farm Labor Agent. When no such representative is available, farmers or workers should apply directly to the Chairman of their County Council of Defense for help or work.

EMPLOYER'S RESPONSIBILITY

To insure a minimum amount of failure, it seems desirable to point out that obligations rest upon both parties to a labor situation.

Housing.—When attempts are made to utilize high school boys or city dwellers it must be borne in mind that these people are accustomed to a decent standard of living. Proper housing is a primary consideration for best results and involves provision for a due degree of privacy, a good bed, facilities for keeping clean, and generally proper sanitary accommodations.

Boarding.—The usual way of paying "so much and found," meaning as it does a cash wage together with board and lodging, can be replaced to advantage by substituting the practice used in most labor camps, other than ranches, where wages are quoted at so much per day with deduction for room and board, as for example, $2.75 for ten-hour day with 75c off for board and lodging. Board and lodging is as much the worker's due as cash wages, and the above method offers an easily measured standard of values for perquisites. Such method further impresses upon the worker the necessity of first meeting his board and lodging before he expects to save on the work he does. Charges for board and room should be based upon the value given. The farmer must recognize that he is competing with city living conditions and if he charges $1.00 per day must give comparable and equivalent value. In general, a relatively high rate for board and room, justified by providing full value, will mean more to the potential supply of labor under discussion, than uncomfortable surroundings at a low charge. Under this plan, the farmer can provide milk, butter, eggs, and similar foods demanded by the men and charge them with the cost. When many men are boarded and conditions will permit, a choice of foods for each meal is desirable.

House facilities, from the farmer's standpoint of investment, must of necessity conform to the amount of time they are in use. Permanent buildings are possible only when labor is employed for long periods of time, but tents, portable cook-cars (and bunk-cars when weather conditions warrant), portable bathing and sanitary condi-

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tions can be arranged for short term work, especially if the equipment is owned jointly by farmers engaged in different lines of work, or by men having a diversity of enterprises not centrally located and calling for labor needs at different periods. Plans of a standard bunk-car and a cook-car are on file in this department for use of all interested, while the State Commission of Immigration and Housing, with offices at 525 Market Street, San Francisco, are ready to give substantial assistance in arranging proper housing conditions.

Wages.—In hiring city men or high school boys best results will follow whenever it is possible to pay for labor on a piece-work basis. Even when working on a piece basis provision should be made for a minimum hourly and daily return, for while piece work is best for untrained men, they are not experienced in farm work and cannot gauge a day's work. This minimum hourly return protects them to a certain extent. The farmer on his part is protected by his ability to discharge anyone with whom he is dissatisfied.

Piece work can be made to apply to all kinds of work—hoeing beans, picking fruits, harvesting corn, cultivating potatoes, digging potatoes, or pitching hay. Whenever feasible it has been found very satisfactory to establish a standard day's work and to pay a fixed bonus per piece to the workers on the days that they reach or exceed the standard.

As a gauge of what wages must be paid, recent conditions have brought about a present standard wage for unskilled labor—on which the farmer largely draws for his surplus needs—of from 25c to 30c per hour, with the general average of 27½c, without board and lodging. Any farmer needing help should expect to pay this equivalent. The minimum guaranted rate should be not less than 25c per hour, with reasonable possibility that under normal average conditions, a normal average workman can make about 27½c, out of which is to come board and lodging.

The use of labor drawn from cities and high schools, is possible only on ranches having much routine work, and able to meet the housing and wage conditions. It will not be cheap labor—and for many kinds of farm work it will not be satisfactory labor, but there are enough situations when such help can be made useful and of economic value to warrant its consideration, such as picking berries, cutting fruit, hoeing, pitching hay, picking cotton, picking up walnuts and prunes, and picking certain kinds of fruit.

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EMPLOYEE'S RESPONSIBILITY

The high school boy or city man who because of patriotic or financial reasons goes into farm work, should carry with him a sense of personal responsibility. After properly investigating an opening and assuring himself that he is willing to try the work, the prospective employee should go to the work with a determination to remain. The average farmer has but little time to break in new men, and cannot afford to be constantly changing green crews. As the employee usually pays his fare to a given job he should first exhaust all nearby possibilities before looking beyond. It is not wise for a man to accept short-term employment at some distant place if his total earnings will be insufficient to pay his railroad transportation there and back. Briefly, the employee's responsibility means that he must go out into the field with the steadfast purpose of doing his best, to put in a full day, do his work in as satisfactory a manner as he is able, and to remain with the work as long as he agrees to at the beginning.

TRIALS WITH POTENTIAL HIGH SCHOOL AND CITY LABOR

When any farmer desires to try out high school boys or city men to test their capabilities and endeavor to utilize their services, this department will attempt to secure the needed help when

1. A proper wage is assured—*i.e.*, a minimum of 25c per hour, out of which the worker is to pay for his board and lodging.
2. When proper living arrangements are available, *i.e.*, clean sleeping quarters, provided with good cots, some degree of privacy, with proper bathing and toilet facilities.
3. When meals are clean, nourishing and reasonably good in quantity, quality, and variety.
4. When charges for board and lodging are not excessive, *i.e.*, 75c to $1.00 per day or the going rate for proper values.
5. When the work to be done by high school boys does not require more than eight hours actual work.
6. When continuous work is available for a period of thirty days or more.

If any farmer, wishing to avail himself of this labor, has less than thirty days' work in sight, he should consider the possibility of co-operation with other farmers needing help in order to insure sufficient work to warrant labor going to him.

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7. When the work is not more than 100 miles from a source of labor.
8. When a sufficient supply of suitable labor is available.
9. When board and lodging is supplied to a respresentative, if high school help is utilized in groups of ten or more.
10. When there is no Sunday work except in well-defined emergencies.

Whenever groups of immature young men are to try farm work, it is desirable (and necessary if sent out by this department) to have a teacher or other qualified person accompany them to oversee their living habits, and general well-being. Such representative should possess the confidence of both boys and parents and have ability to meet with diplomacy and dispatch all conditions necessitating his interference. He should have nothing to do with the work itself, other than to inspire the boys with a due sense of personal responsibility, as the proper conduct of the work itself best rests with the employer. This representative should have privilege of picking men and sending home those not doing proper work.

Whenever an organization with a recognized head offers its services, all details of business will be arranged directly with the representative, who in turn will deal with the individual members of his group. This applies particularly to such organizations as Boy Scouts, Y. M. C. A., high school delegations, or charitable societies.

Whenever unorganized help is offered, this department will furnish the necessary information concerning existing conditions under which the work is to be done, perfect whatever working organization is needed and make the best possible arrangements with the employer.

In offering its assistance to the farmers, this department cannot guarantee either a supply of labor or its efficiency. Neither in formulating the above terms does this department want to appear as if forcing or advocating impossible regulations. But present day conditions and the necessity of safeguarding the health and family interests of the vailable supply warrants as clear-cut a statement of the situation as can be given for the express purpose of showing how matters stand and to insure as high a degree of success as possible in the utilization of such potential labor as we have at hand.

In addition to making every attempt to bring together available labor and farmers in want of labor, this department stands ready to render to the best of its ability a report of existing living and wage conditions, or the kind, number, ages, and condition of help offering services, when requested by one or both sides of any parties interested

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in the growing and moving of crops necessary to the conduct of the war.

In its work this department will count in the future, as it has relied in the past, upon the valuable and active co-operation of the Commission of Immigration and Housing to aid in recommending and passing upon proper conditions in housing and boarding arrangements.

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